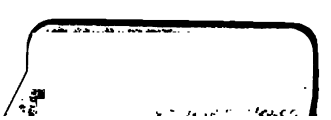

ELEMENTARY PRINCIPLES

OF

FORTIFICATION.

BY

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PREFACE.

IN commencing a revision of Straith's Elementary Essay on Fortification, it was my intention to modify only such portions as the progress of military science had rendered obsolete. It is, however, difficult for one author to adapt his ideas to those of another, and in the progress of the work, so many alterations, transpositions, additions, and omissions appeared desirable, that when finished, little more than the semblance of the original remained.

Under these circumstances, it seemed unfair to cast upon Major Straith, by the retention of his name, a responsibility which belongs more properly to myself, and the volume has, therefore, been issued in my name.

Political events of the last twelve years have rivetted the attention of European Governments to warlike preparations, and have directed to the perfecting of engines of war the great mechanical skill of this and other nations so long almost exclusively devoted to the arts of peace.

The result has already been a complete revolution in fire-arms. Invention has succeeded invention, and improvement improvement, with a rapidity altogether unprecedented. The revolvers of Colt and Adams, the Whitworth, the Enfield, the Lancaster rifles, the breech loaders of Westley Richards, and Terry, leave little to be desired in small arms. Yet these invaluable inventions, triumphs of mechanical skill, appear to be exceeded in importance by the marvellous rifled guns of Sir W. Armstrong and Mr. Whitworth.

What may be the ultimate effects on the tactics of armies in the field, and on the attack and defence of fortified positions, of these extraordinary weapons, must be unravelled by time and by the test of actual warfare.

To enter at length into considerations of this nature, and to speculate on all the changes and modifications which may ensue, would be foreign to the objects of this Elementary Treatise. Such a course could only tend to lead aside the student at the commencement of his studies from the sure paths of ascertained knowledge, into regions at present uncertified by the test of actual experience. There are yet some results too obvious to be passed over. To these, principally relating to the removal of restrictions and limitations assigned by the range of fire-arms hitherto in use, I have endeavoured to give their due weight, while my chief aim has been to direct the attention of the student to those fundamental principles which must remain unaltered, and generally applicable to all cases, even to those in which the details may be very considerably modified.

It only remains for me now to express my obligations to the many writers from whose works I have derived much valuable assistance, and to direct to them the attention of the student seeking for fuller information.

J. T. HYDE.

CROYDON, SEPTEMBER, 1860.

Works chiefly used in the preparation of this Treatise :—

STRAITH'S TREATISE ON FORTIFICATION AND ARTILLERY.
AIDE MEMOIRE TO THE MILITARY SCIENCE.
SIR HOWARD DOUGLAS. MILITARY BRIDGES.
SIR C. PASLEY. PRACTICAL OPERATIONS OF A SIEGE.
SIR J. JONES. SIEGES IN SPAIN.
PAPERS ON FORTIFICATION—ROYAL MILITARY ACADEMY.
COL. HUMPHREY. FORTRESSES IN GERMANY.
COL. JEBB. TREATISE ON OUTPOSTS.

History of the Punjab,

And of the Rise, Progress, and Present Condition of the Sect and Nation of the Sikhs. By THOMAS THORNTON, Esq. 2 vols. post 8vo. cloth, £1. 1s.

Hindu Law,

Principally with reference to such portions of it as concern the Administration of Justice in India. By SIR THOMAS STRANGE, late Chief Justice of Madras. 2 vols. royal 8vo. cloth, £1. 1s.

The Hedaya, or Guide,

A Commentary on the Mussulman Laws. Translated from the original by CHARLES HAMILTON. 4 vols. 4to. £4. 14s. 6d.

Grammar of the Persian Language.

To which are subjoined several Dialogues, with Alphabetical List of the English and Persian Terms of Grammar; and an Appendix on the use of Arabic words, by MEERZA MOHAMMAD IBRAHEEM. Royal 8vo. £1. 1s.

Richardson's Dictionary, Persian, Arabic, and English.

A new and greatly Enlarged Edition (1858). By F. JOHNSON. 4to. cloth, £4.

Introduction to the Grammar of the Sanscrit Language,

for the use of early students. By Professor H. H. WILSON. 2nd edition, 8vo. cloth, 18s.

Dictionary of the Chinese Language.

Arranged in three divisions viz.—

CHINESE AND ENGLISH—according to the Radicals.
CHINESE AND ENGLISH—alphabetically.
ENGLISH AND CHINESE.

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Grammar of the Chinese Language in English.

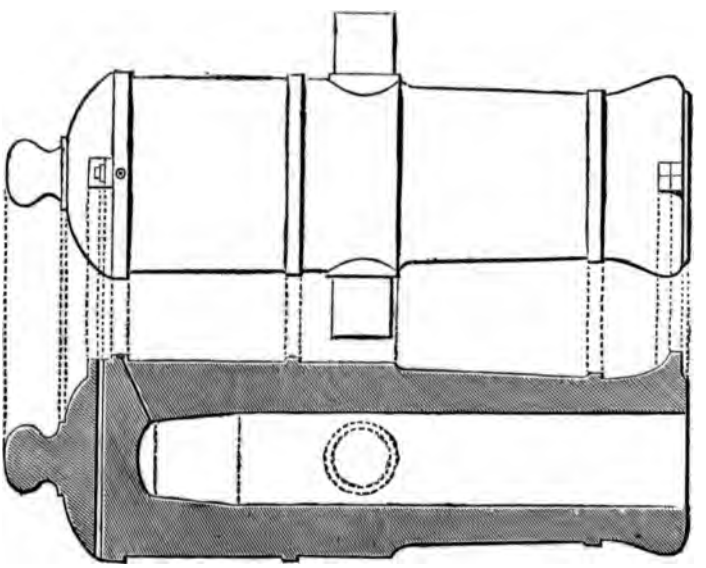
By LEON DE ROSNY, in 8vo. [Nearly ready, price about 12s.]

Glossary of Judicial and Revenue Terms and of Useful

Words occurring in Official Documents relating to the Administration of the Government of British India, from the Arabic, Persian, Hindustani, Sanscrit, Hindi, Uriya, Maratha, Guzarathi, Telugoo, Karnata, Tamil, Malayalim, and other Languages. By H. H. WILSON, M.A., F.R.S. &c. &c. 4to. cloth, £2. 2s.

2. Howitzers, in external form are much like guns. They differ from them in three particulars. 1st. They are shorter. 2nd. They are lighter in proportion to the diameter of the bore. 3rd. They are "chambered" in the bore, *i.e.*, the bore is diminished in size towards the breech. See section in the annexed diagram.

FIG. 2.

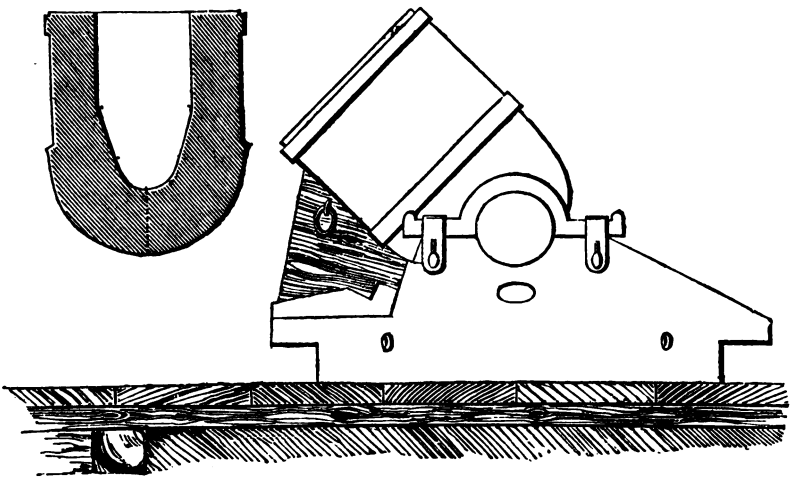


Plan and Section of an 8-inch Iron Howitzer.

Like guns, the larger howitzers are of iron; the smaller, used as field artillery, of brass.

3. Mortars differ greatly from both guns and howitzers, not only in external appearance, but also in the manner of firing. Mortars are very short in comparison with their calibres, and are usually fired at an angle of 45°, variations in range being obtained by alterations in the charge of powder. Mortars, like howitzers, are chambered. The larger classes are of iron, the smaller of brass. Mortars vary in calibre from 13 inches to 4⅘ inches, and the weight of their shells from 193 lbs. to 8 lbs.

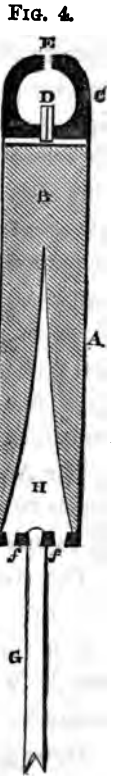
FIG. 3.



Elevation and Section of a 10-inch Iron Mortar.

4. Rockets. The annexed diagram represents a section of a Congreve or war rocket. A is the case, a cylinder of wrought iron, accurately formed and carefully welded, to one end of which is attached the shell C, of cast iron. The interior of this shell communicates with the interior of the rocket, by means of the fuse D. In the point of the shell is an aperture E, through which the bursting charge is introduced, and through which an instrument can be inserted, when necessary, to bore out the composition of the fuse D, to any required length: this aperture is closed by a screw-plug, removeable at pleasure. The base of the rocket is closed by a strong plate of iron, to the centre of which the stick is attached by screwing. This plate is furnished with a number of holes *f f*, equidistant from the centre and from each other, for the escape of the elastic products of the combustion of the composition of the rocket. B is the composition, and H a conical cavity left in driving it. The object of this cavity is, to expose an extensive surface of the composition to combustion at the same time, so that large volumes of gas may be rapidly generated, and produce great pressure in the interior of the rocket.

FIG. 4.



5. The common musket is too well known to need any description. The Enfield rifle musket is altogether a superior arm, more carefully finished and provided with an accurate sight, by which it can be elevated to any required degree, so as to throw its bullet to any given distance within the limits of its range. The Enfield musket is rifled, that is, a number (3) of very shallow, but wide, grooves are cut spirally along the interior surface of its bore, so that an accurately fitting bullet is constrained to follow the sweep of the grooves while passing through the bore. The bullet thus acquires a rotation about its own axis, which it retains during its flight. This rotation admits of the use of elongated projectiles which could not otherwise be employed, whilst it prevents the deviations which result from the accidental rotations always occurring in spherical projectiles discharged from smooth barrels.

6. The Armstrong Gun is a wrought iron rifled cannon. The tube of the gun is formed of strips of the best wrought iron, wound spirally round, and carefully welded together by a series of operations having a considerable resemblance to those employed in the manufacture of the best sporting gun barrels. Thus the enormous strain resulting from the ignition of the charge is received by the iron in the direction of its fibre (which runs round and round the barrel), and therefore in that direction in which its tenacity is greatest. In this gun the great difficulties which have hitherto attended the numerous attempts of making breech-loading cannons have been completely and most satisfactorily overcome, so that almost all the requisites of a perfect gun are satisfied, that is, we have now a gun possessing in a remarkable degree, lightness and strength, durability and celerity of fire, accuracy and extensive range. The range of these guns is enormous. It already exceeds 5 miles, and it will in all probability before long be considerably increased.

The Armstrong 12-pounder weighs only 8 cwt., and requires only 4 horses to transport it with the greatest facility; its practice is accurate up to and beyond 5,000 yards.

The Armstrong 32-pounder weighs 20 cwt., and with a charge of 5lbs. of powder projects its shot nearly 10,000 yards.

It is stated that by means of this weapon a piece of wood 22 inches long by 9 inches broad was struck three times out of 4 shots, at a distance of three quarters of a mile.

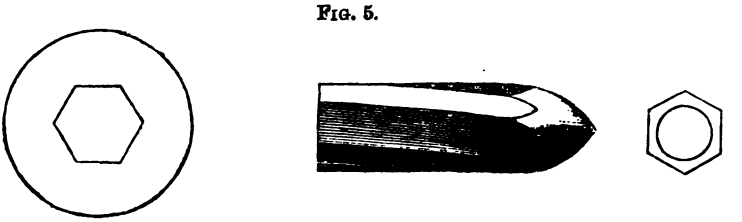
These guns being rifled are enabled to project elongated shells and bullets, which retain the point foremost through the whole extent of

their flight. The shells can therefore be fitted with percussion fuses of the simplest kind, which never fail to explode on striking the object, and are free from the dangers and uncertainties attending the ingenious but intricate concussion fuzes with which spherical shells have been hitherto fitted.

The shells and shot are sugar-loaf shaped, about 2½ diameters in length. They are formed of a number of segments enclosed in a jacket or case, and covered externally with lead.

7. While these sheets are passing through the press, another rifled gun of extraordinary power has been produced, which must not escape a brief notice. Mr. Whitworth, of Manchester, already so celebrated for the unrivalled performance of his rifled small arms, has succeeded in constructing several rifled breech-loading cannon of various calibres, which, as far as they have been hitherto proved, have shown themselves at least equal to those of Sir W. Armstrong. His 3-pounder gun, 208 lbs. in weight, with a calibre of 1½ inches, a charge of 8 ozs. of powder, and an elevation of 35°, projects its shot to a distance of more than 5½ miles, and this with an accuracy truly marvellous. He applies the same principles to his guns which have been so successful in his small arms. He uses a very long projectile, some 3½ diameters in length, that the resistance of the air may be as small as possible, and an extensive range the result. To overcome the tendency of so long a projectile to turn over in its flight, a rapid spin or rotation must be impressed upon it, and this necessitates a more than usually rapid twist in the grooves of the rifle. The bore of the gun and of the small arms is the same in form—hexagonal; but the twist varies with the calibre. In the rifle, with a half-inch bore, one turn is completed in 20 inches; in the 8-pounder gun, with 1½-inch bore, in 3 feet 8 inches. In the annexed diagrams are shown, a section of the barrel, and an elevation and end view of one of the small arm projectiles. An inspection of these figures will convey a correct idea of the form of the interior of the barrel, perhaps more readily than a lengthened description.

Fig. 5.



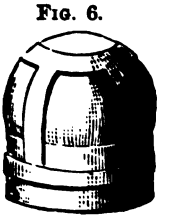
The bore of the barrel is described by its hexagonal section moving parallel to itself from breech to muzzle, and at the same time rotating uniformly about its centre with such a velocity, that it completes one whole rotation while its centre is moving over a space of 20 inches in the small arms and 3 feet 8 inches in the 3-pounder gun. So that the barrel may be considered as a rifle with six grooves, making one turn in 20 inches in the one case, and in 3 feet 8 inches in the other.

The bullets are made of a hard metal, an alloy of 9 parts lead with 1 part tin, and they are shaped to fit accurately the interior of the bore. A side and end elevation of the bullet are shown in the annexed diagram.

8. Projectiles.—From guns are projected round shot, grape shot, case shot, spherical case shot. From howitzers, grape shot, case shot, spherical case shot, common shells. From mortars, common shells.

A Round Shot is a solid sphere of cast iron; when fired from brass guns, it is attached to a wooden bottom, by straps of tin, as in the annexed diagram. Round shot vary in weight from 6lbs. to 68lbs., and in diameter from 3·56 inches to 8 inches. They are used against artillery, troops in column and cavalry; for breaching, for dismounting guns, and in all cases where great penetration is necessary.

Fig. 6.



9. A Grape Shot consists of nine cast iron balls, and is of two patterns. In the old pattern, the shot are piled on an iron plate, round a pin projecting from its centre, covered with canvas and tied with stout cord. In the new pattern the shot are arranged in

Fig. 7.

three tiers between iron plates, secured by a bolt and nut passing through the centre. The number of shot is always nine, but they vary

in weight from 8 oz. to 4 lbs. each, according to the calibre of the gun from which they are fired. Grape shot are used almost exclusively against troops, and at suitable ranges are very destructive.

10. Common Case or Canister Shot are tin canisters, containing a quantity of small shot varying in weight from 8 oz. to 1¼ oz., and in number from 90 to 34, according to the nature of the gun. The canister, which of course corresponds with the calibre of the piece, has an iron or a wooden bottom placed next to the cartridge; an iron bottom bears the explosion best, and causes it to act equally in propelling the small balls; whereas a wooden bottom being immediately torn to pieces, the small balls begin to scatter sooner, and are not so effective in their range. From the small weight of the balls, and their separating the moment they quit the piece, the ranges are not great; but within its range, canister shot is more destructive than any projectile.

11. Spherical Case Shot, or Shrapnel Shells.—A spherical case shot consists of a thin shell of cast iron, containing a number of musket balls, and a charge of powder sufficient to burst it, a fuse is fixed to it as in an ordinary shell, by which the charge is ignited and the shell burst at any particular instant. A spherical case shot, when loaded ready for use, has about the same specific gravity as a solid shot, and therefore, when fired with the service charge of powder, its range, and its velocity at any point in its range, is about equal to that of a solid shot of the same calibre. Now a musket ball is effective when discharged with a velocity equal to that which is retained by a 6 or 9-pounder solid shot after having passed over a distance of 1,000 to 1,200 yards. If, therefore, a spherical case shot be projected from a gun with the usual service charge, and be made to burst at a distance of 1,000 or 1,200 yards from the gun, the musket balls contained in it will possess at the instant after its explosion the same velocity and direction as that of the shell at the moment when its explosion took place; that is, they will be projected from the point at which the shell exploded, and in the direction in which the shell was moving at the moment of its explosion, with a velocity quite sufficient to render them effective.

12. The Common Spherical Case Shot was liable to burst before the proper time, and its use was attended with so many inconveniences as greatly to diminish its value. These have been now removed and the shell remodelled, and so greatly improved by Captain

Boxer, R.A., that it may be considered one of the most formidable projectiles of the present day.

In the annexed diagram are representations of two forms of Captain Boxer's improved Spherical Case Shot.

Fig. 8.

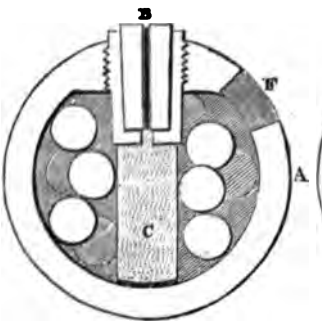
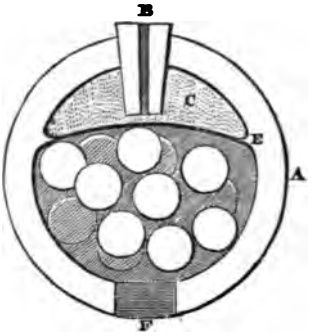


Fig. 9.



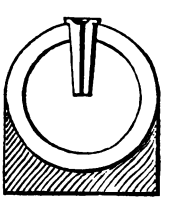
A is the shell, B the fuse, C the bursting charge of powder.

In either case it is evident that the bursting charge of powder is kept separate from the balls. In fig. 8 it is contained in a cylindrical tin box, attached to a brass socket which receives the fuse, and which is screwed into the shell. In fig 9 the part of the shell containing the bursting charge is separated from that containing the bullets, by a diaphragm of sheet iron E cast into the shell (*i. e.* the shell is cast on to the diaphragm which is inserted into the core).

The bullets are introduced into the shell by a second orifice F, and are kept in their places by a composition afterwards poured in.

13. A shell (fig 10), is a hollow sphere of cast iron, strong enough to resist the explosion of the charge of the piece from which it is thrown. It has a round plug or fuse-hole to receive the fuse, by which it is made to explode at pleasure. The fuse is a plug of wood having a small cylindrical cavity down its centre, into which a dry mealed powder or fuse composition is driven so exceedingly hard, as to burn very slowly, at the rate of ·2 of an inch per second. Its length being proportioned to the time of flight. It is very tightly driven into the fuse-hole of the shell (which is previously loaded with its charge of bursting powder), and the shell is placed on the charge in the piece, with the fuse outermost. On

Fig. 10.



firing the mortar, the elastic fluid generated by the explosion of the charge, surrounds the shell and ignites the fuse, which continues to burn during its flight, and being cut so as to burn out (except with spherical case) as the shell falls on the object, the bursting powder is ignited in the shell, the shell is shattered by the explosion, and its fragments are driven with great force to considerable distances.

14. Ranges and Penetrations.—The extreme ranges of smooth-bored guns firing solid shot may be considered to vary according to their size, from 2,000 to 4,000 yards. These great ranges, are only attained by firing at great elevations, and the practice at such distances is consequently uncertain. Ranges of 1,000 to 1,200 yards for field guns and of 1,500 to 2,000 yards for heavy guns are as great as can be secured with anything like accuracy. It seems, however, more than probable, that smooth-bored guns will, before long, be altogether superseded by rifled ordnance, and reasoning from what has been already accomplished, we may at least expect to double the present ranges, and greatly to increase the accuracy of fire.

The ranges of grape shot are equal only to the ranges of the individual balls of which the grape shot is composed, they are, therefore, subject to considerable variation, according to the dimensions of the gun from which the grape is discharged. The most effective ranges for grape shot may be considered to lie between 300 and 600 yards.

The range of case or canister shot is very limited. From the small size of the bullets they rapidly lose their initial velocity. The range for case shot is limited to 300 yards; beyond this distance grape shot is to be preferred. At ranges below 300 yards case shot against bodies of troops is very destructive.

Spherical case shot is effective at much greater ranges than case or grape shot. It may be employed with good effect at any distance between 600 and 1,500 or even 1,800 yards.

The ranges of shells vary according to their size from 1,000 to 4,000 yards. They are fired either from mortars or guns. With the method of firing them from mortars at an elevation of 45° with a charge of powder proportioned to the range desired, any great accuracy of practice is not to be expected.

15. The penetration of a solid shot varies with its diameter, and with the distance and material of the substance penetrated; other circumstances being the same, the penetrations of shot of different diameters are proportional to their diameters.

In the subjoined table are given the penetrations of a 24-pounder shot, whence a tolerably accurate estimate may be formed of the penetrations of shot of other calibres.

Penetrations of a 24-pounder iron shot into—

Substance Penetrated.	RANGE.			
	100 yards.	400 yards.	1,200 yards.	Penetration in feet.
Good Masonry .	2 ft.	1½ ft.	¾ ft.	
Oak	4 „	3 „	1½ „	
Firm Earth . .	6½ „	5 „	2½ „	
Fresh dug Earth .	12 „	9 „	4½ „	

Shells may be considered as round shot of a lower specific gravity, and their penetrations are therefore proportionately less.

A bank of earth, to afford a secure cover from heavy guns, will require a thickness from 18 to 24 feet. In guns below 18-pounders, if the number of the feet in thickness of the bank be made equal to the number of lbs. in the weight of the shot by which it is to be assailed, the requisite protection will be obtained.

Wrought iron plates 4½ inches in thickness will withstand the effects of 32-pound shots, and of all inferior calibres at short ranges as 400 yards. Plates of this thickness, however, are soon destroyed by 68 pound shots, and seem to afford little protection from the elongated shots of the new rifled ordnance.

To resist successfully the fall of heavy shells, buildings must be covered with arches of good masonry, not less than 3 feet thick, having bearings not greater than 25 feet, and these must be again protected by a covering of several feet of earth.

Iron plates half-an-inch thick, oak planks 4 inches thick, or a nine-inch brick wall, are proof against musketry or canister at a range of 100 yards.

Iron plates 1 inch thick, oak from 8 to 10 inches thick, a good wall a foot thick, or a firm bank of earth 4 feet thick, will afford secure cover from grape shot, from any but the largest guns at short ranges.

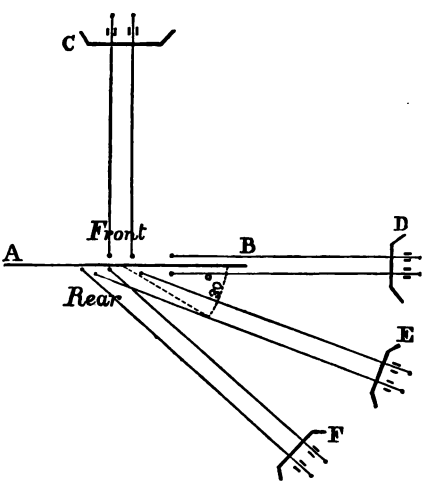
The common musket will drive its bullet about a foot and a half into well-rammed earth, or it will penetrate from 6 to 10 half-inch elm boards placed at intervals of an inch.

The Enfield rifled musket makes excellent practice up to 600 yards, and in skilful hands to 1,000 yards; its penetration is about twice that of the common musket.

16. Varieties of Fire. Figure 11.—When a battery of guns or a line of infantry are arranged parallel to a line of parapet, or of troops, so that the direction of the shot, or line of fire, makes a right angle with the line of parapet or of troops, the fire is said to be *direct*.

This variety of fire is employed in breaching parapets or walls, against troops in column, and in most cases where the object of attack is possessed of considerable depth or thickness.

FIG. 11.



A B represents a line of parapet, or of troops.
C is the position of a battery, or line of infantry for direct fire on A B.
D ... ... for enfilade.
E ... ... for slant.
F ... ... for reverse.

When a battery of guns, or a line of infantry is arranged at right angles, to the prolongation of the line of parapet, or of troops assailed, so that the line of fire is coincident with the line of parapet, or of troops, the fire is said to be *enfilade*.

This species of fire with heavy ordnance, full charges and solid shot, is especially effective in those circumstances which admit of its adoption, a single shot having been known to disable several guns, or to strike down a whole rank file of men.

When guns are fired with small charges at considerable elevations, so that the shot in descending strike the ground at a considerable angle, and afterwards make a succession of bounds, they are said to fire *à ricochet*.

Enfilade fire à ricochet is generally employed to dismount guns on parapets, protected by traverses, at ranges varying from 400 to 600 yards.

When a battery of guns, or line of infantry is placed in flank and in rear of a line of parapet, or of troops, so that the line of fire meets the interior slope of the parapet, or the rear of the line of troops at an angle not greater than 30°, the fire is said to be *slant*.

When this angle is greater than 30° the fire is said to be *reverse*.

Vertical fire is the firing of shells from mortars at great elevations, usually 45°.

CHAPTER II.

OBJECTS OF FORTIFICATION.—PARAPETS.—DITCHES.—COMMAND.—OUTLINE OR TRACING.—REDAN-TRACE.—TENAILLE-TRACE.—BASTION-TRACE.—VAUBAN'S FIRST SYSTEM.—DEFECTS OF.—CONSTRUCTION OF.

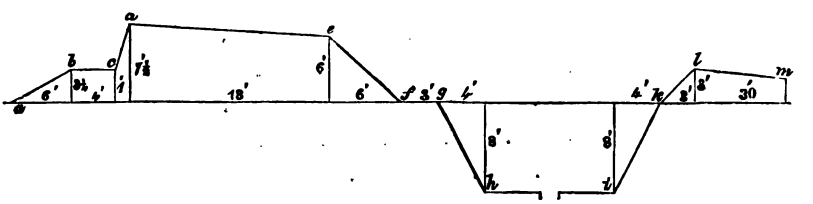
17. The object of fortification is to provide a body of troops, or a town, with a secure protection against a sudden assault of superior numbers, against the effects of the projectile weapons mentioned in the foregoing chapter, and finally to enable the garrison to use the same weapons to the greatest advantage against their assailants.

Protection from an enemy's fire must be secured by the interposition between the contending parties of a screen or parapet of some material capable of resisting the effects of the missiles discharged against it.

This parapet may be made in exceptional cases of very miscellaneous materials, but under ordinary circumstances it will be formed of earth, which is almost always obtainable, and will be excavated from a ditch, which will itself offer an obstacle to attack. This parapet of earth will vary in height and thickness according to a variety of circumstances. It must, however, possess a certain definite shape, depending upon natural laws, and therefore subject to little variation.

The usual figure of a parapet with its ditch is shown in the annexed section, to which the names of the several slopes are added.

FIG. 12.



a b, slope of the banquette; *b c*, tread of the banquette; *c d*, interior slope of the parapet; *d e*, superior slope of the parapet; *e f*, exterior slope of the parapet; *f g*, berm; *g h*, escarp of the ditch; *h i*, ditch; *i k*, counterscarp of the ditch; *k l*, interior of the glacis; *l m*, slope of the glacis.

The exterior slope *e f*, which is always exposed to the action of the weather, and during an engagement, to the stroke of the enemy's shot must have that inclination or slope which the materials composing it would assume when poured loosely from a height, and at which they would therefore stand without any additional support. This inclination for earth of ordinary tenacity, is about 45°, *i.e.*, the base on which the slope stands is equal to its height, or it has a depression of 1 in 1.

The parapet would afford the best cover if its superior slope, *d e*, were horizontal, or rather parallel to the plane of site, but in this case a musket shot fired along its surface, could not reach the ground within a very considerable distance in front of it; a gentle inclination is therefore given to it, but this must not be too great, or the parapet will become so weakened towards its upper edge (called the *Crest*) as to be easily penetrated by the shot of the assailant.

Experience has fixed this slope at a depression of 1 in 6.

The interior slope, *d c*, of this parapet must be nearly vertical, that soldiers may lean against it and fire easily over it. It must, therefore, be supported by a wall of some material (called a *Revetment*).

The base of this slope is usually one-fourth the height. It has a depression, therefore of 4 in 1. A step, *b c*, called the *Banquette*, is added, of a height sufficient to enable a man of ordinary stature to fire conveniently over the crest, and sloping away gently towards the rear to facilitate the alternate advance and retirement of each soldier to discharge and load his firelock. The base of this slope is usually $1\frac{1}{2}$ to 2 times the height. The depression is, therefore 1 in $1\frac{1}{2}$ or 2.

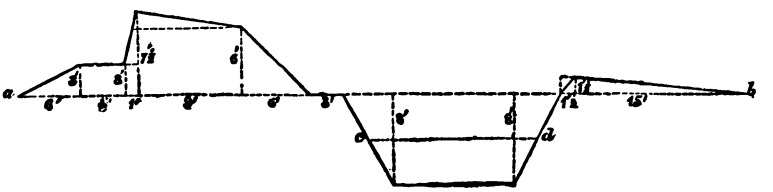
19. The thickness of a parapet, that is, of its superior slope, must be sufficient to withstand the effects of the projectiles likely to be discharged against it. To afford security against

	Its thickness must be
Musketry	5 feet.
6-Pounders	6 feet.
9-Pounders	9 feet.
12-Pounders	12 feet.
18-Pounders	18 feet.
24-Pounders and heavier Guns	20 to 24 feet.

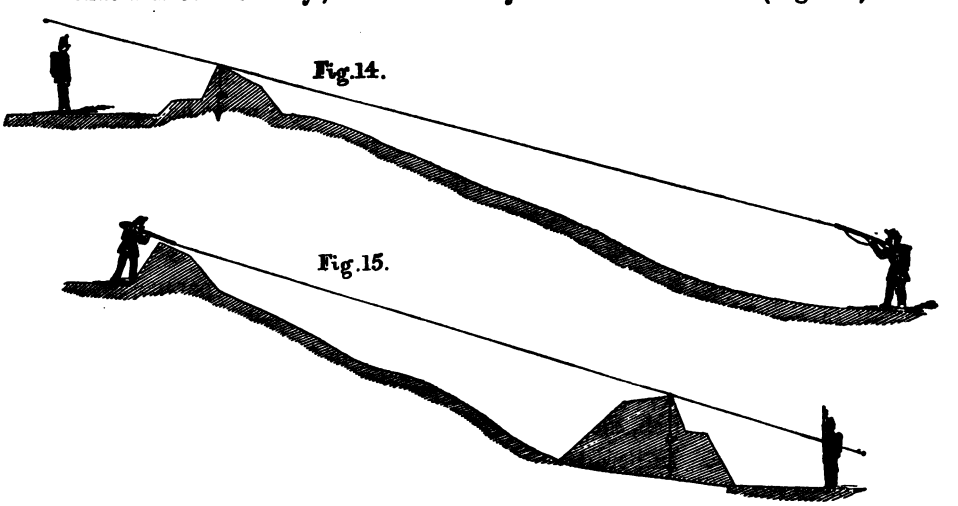
In field works, which are seldom made to resist heavy artillery, a thickness of parapet of 12 feet will generally be sufficient.

20. The height of a parapet will greatly depend upon its position. It will readily be seen from the annexed diagram, that a bullet striking the parapet near the upper part will have to traverse a small portion only of the thickness of the parapet in order to pass through.

Fig. 13.



It becomes necessary, therefore, to give to a parapet a height rather greater than that to which cover is required. Hence on a plain where the attacking and defending parties are on the same level, the height of a parapet, to furnish cover to men 6 feet high, is usually 7½ feet. Should the parapet be situated upon the brow of a hill, the defenders could obtain cover to any desired extent by merely retiring from it. In this case a height sufficient to protect the soldiers while firing is all that will be necessary; this will usually be from 4 to 6 feet. (Fig. 14.)

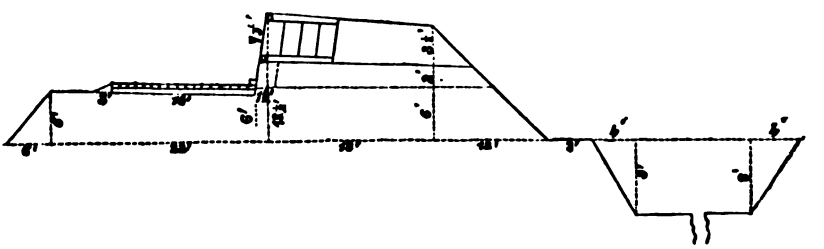


Should these conditions be reversed, that is, should the attacking party be in possession of the higher ground, a height of parapet up to 10 or 12 feet may be indispensable, and when the slope of the ground is considerable, even this will afford cover to a small distance only behind it. (Fig. 15.)

It may be said then, generally, that the height of parapets varies from 4 to 12 feet, and the thickness from 4 to 25 feet.

In works of an important character it is generally necessary that the guns should be elevated above the level of the ground, to enable them to fire over works in their front, to search into hollows in the ground, and to give a plunging fire on an assailant's works. In this case the parapet is mounted upon a wide bank of earth, called a rampart. This construction is shown in the annexed diagram.

FIG. 16.



The ramparts of permanent works are generally of larger dimensions than that shown in the diagram, varying in height from 10 to 30 feet, and in thickness from 50 to 100 feet.

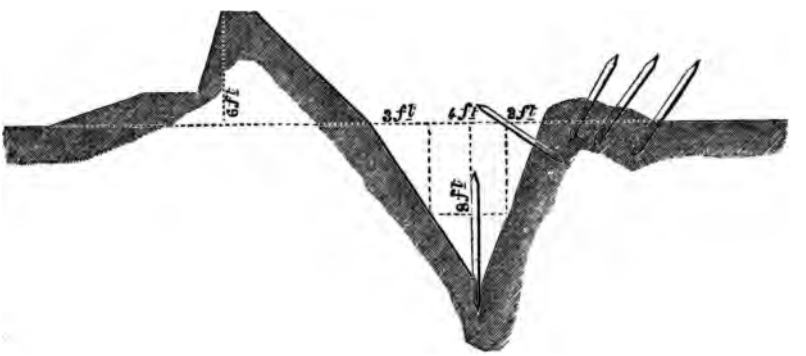
22. Earth, for the construction of a rampart or parapet, must be provided either from a trench in rear or a ditch in front. In either case the quantity excavated from the ditch or trench must be equal to the quantity required for the parapet. In the execution of permanent works the proper arrangement of these details requires much careful calculation. In field works, an approximation sufficiently accurate for practical purposes will result from making the area of the section of the ditch equal to $\frac{10}{11}$ths of the area of the section of the parapet.*

A trench in rear of the parapet is the plan usually adopted when cover is the only object of the work. A ditch in front when an obstacle is to be opposed to the advance of an attacking force. The more formidable the ditch, the more formidable will be the obstacle presented by the works. In permanent works the ditch is usually sufficient to secure the place against all probability of successful attack by coup de main. It is wide (from 50 to 150 feet) and deep (from 15 to 30 feet), its sides are nearly or quite vertical, and are supported by massive masonry walls (called Revetments). In field works such a construc-

* The volume of earth is increased about one-tenth by excavation.

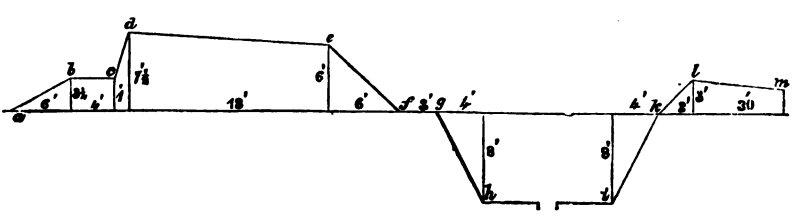
tion is impossible, and as the sides of ditches can seldom be revetted, they can seldom be vertical. They should be made as steep as the nature of the soil will allow, and the width should be about $1\frac{1}{2}$ times the depth. The ditches of field works cannot always be defended by a flanking fire. In this case it will be frequently advantageous to continue their sloping sides to meet in an angle at the bottom, as in the diagram.

Fig. 17.



A parapet and ditch present the greatest obstacle to assault when the exterior slope and escarp of the ditch form one continuous slope, as in the foregoing diagram. It is frequently desirable to sacrifice the advantages attending this construction, in order to secure the greater stability and durability of the parapet and ditch, resulting from the formation exhibited in Fig. 18, where a narrow step, called a berm,

Fig. 18.



usually two or three feet wide, separates the exterior slope of the parapet from the escarp of the ditch. This berm is, moreover, useful to the workmen in the formation of the parapet, but it lessens the defensive properties of the work by assisting an enemy in the assault.

23. In the ramparts of permanent works a berm of this kind is frequently left, but in this case it is considerably wider, usually 8 to

10 feet, and it is protected in front by a loopholed wall of masonry, from which a strong musketry fire can be given over the works in front. It then takes the name of the Chemin des Rondes; it is exhibited in the annexed diagram, Fig. 19.

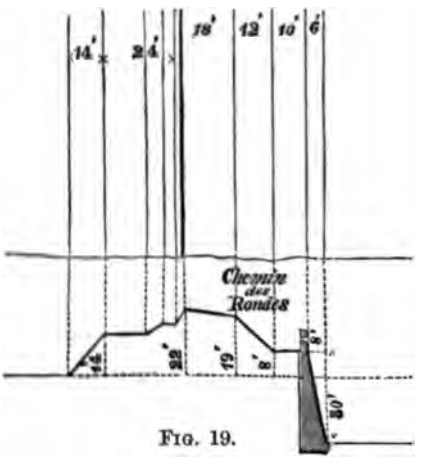


FIG. 19.

24. Relief and command. The height of the crest of a work above the plane of site is its relief. The difference in relief of two works is the command of the one over the other.

It is frequently necessary that two or more works, or lines of works, one behind the other, should deliver a simultaneous fire to the same point on the plane of site; that this may be possible the reliefs must be so arranged that the hindermost work or works may be able to direct its fire to the required spot, over the heads of, and without injury to, the defenders of the works in front, that is, the track of the shot from the hindermost work must pass clear of the heads of the defenders upon the foremost work by at least 4 feet. When this is the case, the hindermost work is said to have a command of fire over the work in front.

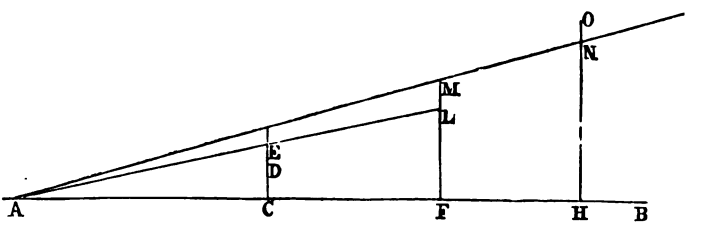
25. The necessary relief to effect this may thus be found:—

Let A B represent the plane of site, A the point to be reached by the simultaneous fire of three parapets situated at C, F, and H respectively. Let C D be the height of the parapet at C. It is required to determine the relief which must be given to those at F and H.

Produce C D to E, making D E equal to 4 feet.

From F and H draw F M, H O perpendicular to A B; join A E and produce it to meet F M in L.

FIG. 20.



Then L A is the track of the shot from the parapet at F. If the fire from the parapet at F consists of musketry alone, L will be its crest; if of artillery and musketry together, the crest will be 4 feet higher than this point. Produce F L to M, making M L equal to 6 feet in the former case, or 10 feet in the latter case; join A M and produce it to meet H O in N. N A is the line of fire from the parapet at H.

As in the former case, the point N will be the crest, if the fire consists of musketry only; if of musketry and artillery together, the crest will be 4½ feet higher.

To find F M—

$$F\,M = L\,M + F\,L = 10\tfrac{1}{2} \text{ feet} + F\,L.$$

By similar triangles—

$$\frac{F\ L}{A\ F} = \frac{E\ C}{A\ C} \text{ or } F\,L = A\,F.\ \frac{E\,C}{A\ C}$$

To find H O—

$$H\,O = H\,N + N\,O = H\,N + 4\tfrac{1}{2} \text{ feet.}$$

By similar triangles—

$$\frac{H\,N}{A\,H} = \frac{F\,M}{A\ F} \text{ or } H\,N = A\,H.\ \frac{F\,M}{A\ F}$$

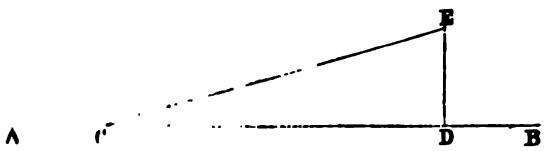
26. To find the greatest relief which can be given to a work, the fire of which is required to reach the plane of site at a given point.

The depression which can be given to the musket of a soldier firing over a parapet, or to a gun firing through an embrasure, is limited by the depression of the superior slope of the parapet in the one case, and by that of the sole of the embrasure in the other. The nearest point then on the plane of site which can be reached by the fire from a

parapet, will be the point in which the prolongation of this slope, in either case, meets the plane of site.

The depression of these slopes can seldom or never exceed 3 feet in 18, or 1 in 6. Assuming this to be the usual depression

FIG. 21.



The problem is stated thus—

Let A B be the plane of site, C the point on it which must be reached by the fire from a parapet situated at D. It is required to find the greatest relief which may be given to the parapet at D. And solved thus:—From D draw D E perpendicular to A B and equal to one-sixth of C D. Join C E, then E C is the track of the shot which will graze along the superior slope of the parapet, or sole of the embrasure at E, whence D E is the height of the crest of the parapet for musketry at D, and D E + 4½ feet for artillery.

Hence, the fire of a work can never be directed to a point on the plane of site nearer to it than six times its own relief, or to a point on the bottom of a ditch nearer to it than six times its own relief added to six times the depth of the ditch.

27. On the disposition of the defensive masses, or the trace. The use of thick earthen parapets is attended with an inconvenience which must be well considered in arranging the trace or disposition of the parapets of a work. The depression of the superior slope is very small, usually one in six. The distance in front of the crest at which this slope produced reaches the ground, is therefore equal to six times the height of the parapet. Along this superior slope, the musket of the soldier is laid in firing, and cannot be depressed below it, whence it follows that in front of every work, provided with a parapet of the usual form, there exists a strip of ground, in width equal to six times the height of the parapet, more or less unprotected by its fire. It is obvious too that a ditch can receive no defence from the parapet immediately behind it, and that unless it be exposed to the view and fire of a more distant parapet, it becomes a place of security for an assailant to collect in force, preparatory to a rush over

the parapet, or for his miners to carry on their operations unmolested against it.

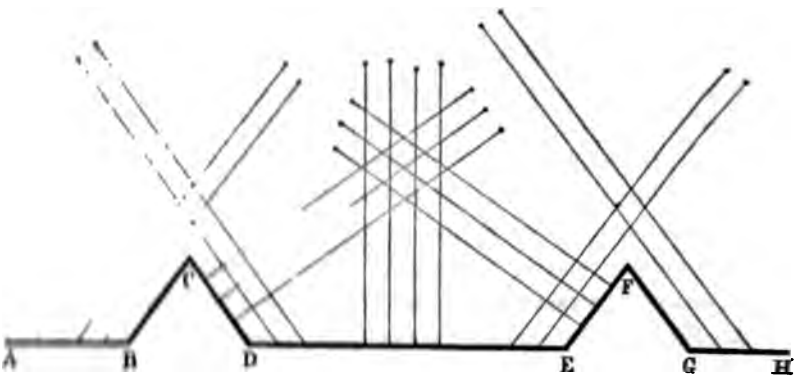
Now it may be considered a fundamental maxim of fortification, that no spot, either on the ground or in the ditch, thus undefended by a fire (technically called dead ground), can be suffered to exist in the immediate neighbourhood of a properly fortified position. It becomes therefore necessary to select such an arrangement, or tracing of the parapet, or by other means to provide, that the dead ground in front of one part may be thoroughly swept and commanded by the fire of some other part of the same, or of some other work.

28. Suppose the simplest conceivable case, that there are two bodies of troops on a plain, the one attacking, the other defending, and suppose the latter to have thrown up for its protection a parapet of earth, and a ditch extending in a straight line of indefinite length, behind which it is awaiting the advance of its assailants. Now, in attacking such a line there is no reason for selecting one point in preference to another, and it is, therefore, impossible for the defenders to predicate the point which the enemy may choose for his assault—the whole must therefore be equally guarded; and for that purpose the defending force must be equally distributed throughout the length of the line. The assaulting column approaches under the direct fire of a small portion only of the parapet immediately in its front, and is opposed only by the defenders of that part, aided perhaps, by a support from the rear. The defenders of the whole length of the parapet, with the exception of that part immediately attacked, being unable to assist in the defence. Moreover, as the column approaches the parapet, the fire becomes less formidable, and when they arrive at the ditch they are perfectly safe, and can collect in force and reform for a rush at the parapet.

29. A slight modification in the outline or trace, obviates many of these defects, and is the first step towards a flanking system.

Thus, if the right line be broken, at intervals, into salient and re-entering angles, as shown in the diagram (Fig. 22). The portions of the original line A B, D E, G H, &c., will furnish a direct fire to the front, which will be crossed in two directions by the fire of the salient faces, as D C, E F, &c. These faces again can be defended by an oblique fire from the original parapet, and this oblique fire parallel to the one face will cross that parallel to the other face in front of the salient, as at C. Now, should an enemy advance to assault the

FIG. 22.



parapet between D and E, he encounters a direct fire from the parapet D E, and a fire upon each flank from the faces D C, E F, respectively, and this flanking fire could be kept up until the moment of his mounting the parapet. It is well known that a flank fire disorganizes troops with greater rapidity than any other, and so great is the moral and physical effect of a direct and double flank fire of this kind, that it is a fundamental maxim never to assault a re-entering angle.

Thus it becomes imperative on the attacking party to assault one or other of the salient angles, and this simple modification of the trace has produced these results:—

1st. The points liable to attack are few in number, and at these points strong bodies of troops may be stationed to repel them.

2nd. In advancing to the assault the attacking force will encounter a strong cross fire.

3rd. The dead ground and ditches are partially defended by an oblique fire.

30. This arrangement is not perfect, inasmuch as

1st. The flanking defence is oblique, and therefore only suitable for musketry defence.

2nd. Dead ground still remains in the ditches in the neighbourhood of the re-entering angles.

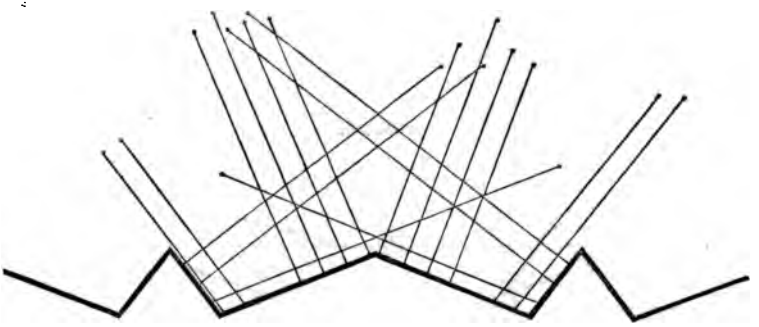
3rd. The salient faces are exposed to the enemy's enfilade.

This arrangement of the parapets is called the Redan Trace.

31. The obliquity of the flanking defence may be reduced by breaking up the curtains so as to form obtuse salient angles, as shown

in the diagram (Fig. 23). It is a question whether the advantages

FIG. 23.



obtained from this charge are equivalent to the defects resulting from it.

It is true that the flanking defence is more direct, but this improvement is secured at the expense of the following evils :—

1st. All the faces are exposed to the enemy's enfilade.

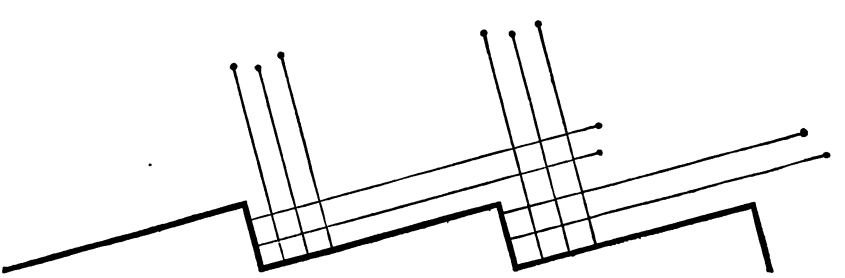
2nd. The number of salients, and therefore of points of attack are increased in the ratio of 3 to 2, while the dead angles remain as before.

3rd. The extent of the crest line is increased, entailing the expenditure of more labour and time in its construction, and requiring more men for its defence.

This arrangement is called the Tenaille Trace.

32. This trace, in a modified form, is adapted to particular situations, and may be used with advantage when the long faces can be directed upon inaccessible ground, so that they may not be enfiladed. It is called the indented or cremaillere trace, and is shown in Fig. 24.

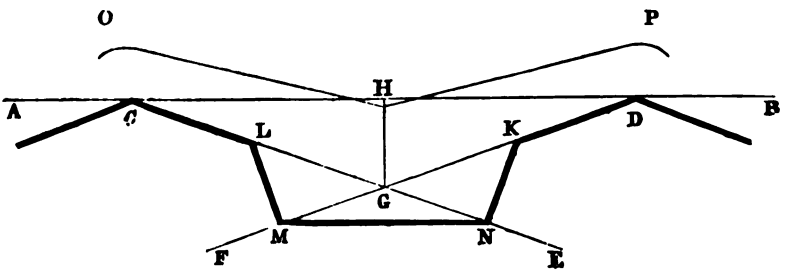
FIG. 24.



It possesses properties nearly identical with those of the tenaille trace just described.

33. The next and most important arrangement is that shown in Fig. 25. It was introduced for the purpose of securing a perfect flanking defence for the ditch, in which it is eminently successful. It is called the Bastion Trace.

FIG. 25.



A B, the line to be defended, is first divided into convenient portions varying in magnitude according to circumstances. Each of these portions is then bisected as C D in H. From this point a perpendicular is drawn, as H G, equal in length to $\frac{1}{8}$th, $\frac{1}{4}$th, or th of C D. Through the extremities of this line, and through the points C and D are drawn C E, D F the lines of defence. Points K, L, on these lines, are then laid off, such that C L, K D are each equal to $\frac{2}{3}$ths C D, or sometimes to $\frac{1}{2}$ C G. The points C and D are then successively taken as centres, from which with the radii C K, D L, arcs are described cutting the lines of defence in M and N. The chords M L, K N, of these arcs are then drawn, and the points M and N are joined.

The line C L M N K D forms one front of the bastion tracing, C L, D K are called faces, L M, K N flanks of the bastions, M N the curtain. To obtain the ditch take C, D respectively as centres, and with radii of the required length describe arcs; from these arcs draw tangents to the points K and L, intersecting in H. O HP is the counterscarp of the ditch.

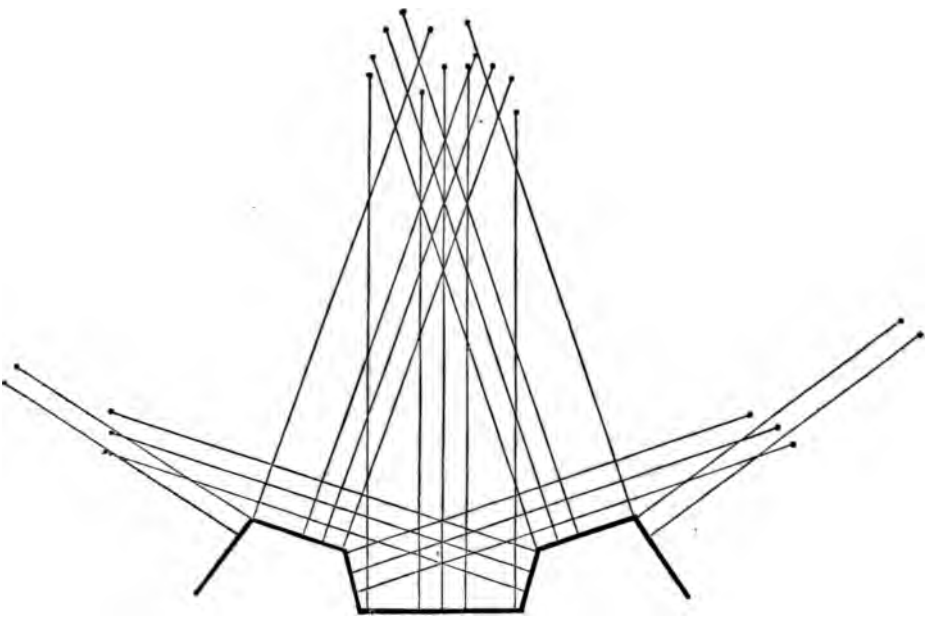
34. The relief of the parapet is so arranged that the fire from the flank K N reaches the bottom of the ditch in the line G H, and defends the whole of it from this line to the salient C, while that from the flank L M, in a similar manner, defends the ditch from H G to D, the whole of the ditch is thus completely defended.

The Bastion Trace possesses the following properties:—

1st. Its ditches are fully and effectually flanked.

2nd. The ground in front of the curtains is defended by a strong direct fire, and by the cross fire of the two adjacent faces of the

FIG. 26.



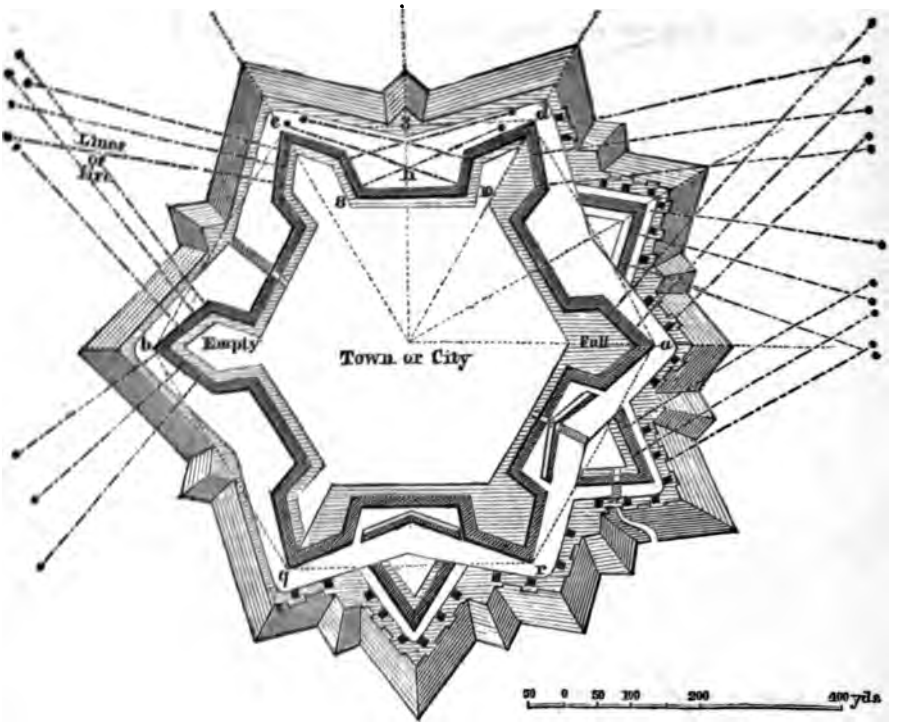
bastions. The flanks give a flanking fire, but not a very strong one to the faces of the bastions, and a weak cross fire in front of their salients.

3rd. The weak points are the salients of the bastions. Here there is a large sectoral space undefended by a direct fire, and feebly swept by the distant fire of the flanks. A remedy for this defect is found by the construction of additional works beyond the ditch, as will be shown hereafter.

4th. The faces and flanks are liable to be enfiladed by an enemy.

35. When a town or a city is to be fortified with a trace of this kind, it must first be surrounded by a polygon, which on a perfectly level plane, would be regular. On each side of this polygon a front of this tracing would be laid down, and the fortress would take something of the form exhibited in the annexed diagram. (Fig. 27.)

FIG. 27.

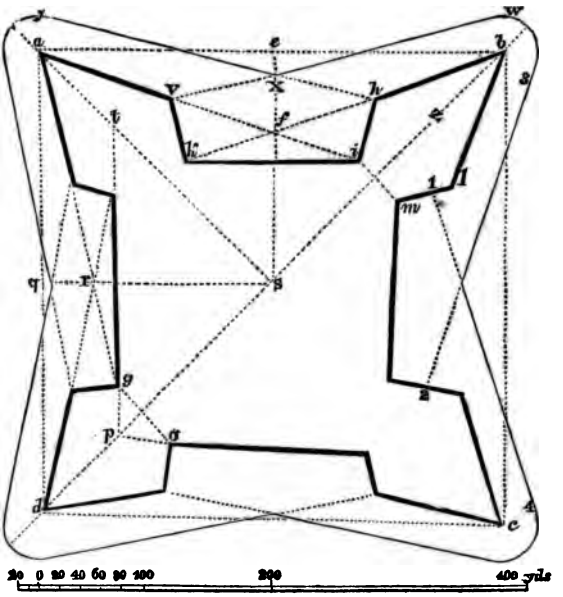


The number of the sides of this polygon, and therefore the number of fronts in the work, would depend partly upon the size of the place, and partly upon the length which it might be considered advisable to assign to the side of the polygon. How this is determined will be shown hereafter.

86. In this trace the bastions are the most important parts. On their faces are mounted the heaviest batteries to sweep the ground in front, while the defence of the ditch is almost entirely entrusted to the fire of the flanks. It is necessary, then, that both faces and flanks should be as extensive and powerful as circumstances will admit. Again, it is desirable that the salient angle of the bastion should be as large as possible, that there may be space for working the guns close up to it, and that the sectoral space in front of it, undefended by a direct fire, may be reduced to a minimum.

Thus, when the length of the exterior side is fixed, the length of the flanks depends upon the length which may be assigned to the

Fig. 28.



Scale of yards for Fig. 28.

REFERENCES TO FIG. 28.

a b, b c, c d, d a	Exterior sides of the polygon.	g o	Gorge of the bastion p
p t	Interior side of ditto	k i	Curtain
e f	The perpendicular.	l b h	Flanked Angle of the
a i, b k	Lines of defence.	b h i	Shoulder Angle Bastion
i h b l m	A bastion	h i a	Angle of defence
b l	Right face of the	h i k	Curtain angle
b h	Left face Bastion z.	e b f	Diminished angle of the polygon
l m	Right flank	S b, S a	Oblique radii
h i	Left flank	S e, S q	Right radii
o p, g p	Demi gorges of the bastion p	b h i k v a	Escarp of the
		w x y	Counterscarp main ditch

$$a\,b = 360 \text{ yards.}$$

$$e\,f = \frac{a\,b}{6}$$

$$b\,h = \frac{2\,a\,b}{7}$$

$$r\,q = \frac{a\,d}{8}$$

faces of the bastions and to the perpendicular, so that the length of the flank will be increased either by shortening the faces or by lengthening the perpendicular. Now for the reasons just stated, the faces cannot well be reduced below $\frac{2}{7}$ths the length of the exterior side,

and being fixed at that amount the length of the flank will depend only upon the length which can be given to the perpendicular.

Now, as the perpendicular increases, the salient angles of the bastions diminish, and it is found that $\frac{1}{5}$th of the exterior side for hexagons and superior polygons, $\frac{1}{4}$th for pentagons, and $\frac{1}{3}$th for squares, is the maximum length which can be assigned to the perpendicular, without reducing the salient angles of the bastions to such narrow dimensions, as greatly to interfere with the power and efficiency of the bastions.

37. Thus the dimensions of the enceinte being obtained, it remains to determine the relief.

The fire of the flank, and therefore the superior slope of the flank produced, must reach the bottom of the main ditch, where it is traversed by the perpendicular, otherwise dead ground would exist there. The depression of the superior slope being 1 in 6, the relief of the flank must not exceed $\frac{1}{6}$th of its distance from the perpendicular—that is $\frac{1}{12}$th the length of the curtain is the maximum relief for the flank. Again, the fire from the face of the bastion, after clearing the crest of the glacis by 4 feet, must be able to reach the plane of site at the foot of the glacis, whence, by the principles of command (paragraph 25) the minimum relief of the face of the bastion is determined.

38. In Vauban's time, the length which could be given to the exterior side so as to secure an efficient defence for the ditch, was very limited on this account. It was necessary that the whole of the main ditch, from the centre of the curtain to the salient angle of the bastion, should be within the musketry range of the flank. This line of defence could not then safely exceed the range of the muskets in use at that time. It was, therefore, limited to about 300 yards, by which the exterior side became also restricted to about 350 or 360 yards.

A front of 360 yards gives a curtain of about 140 yards, and allows, according to the principles already laid down, a relief of about 35 feet, which may be increased to 44 feet, when the central portion of the ditch is occupied by a caponniere. A relief of this extent gives revetments of a height sufficient to render escalade very difficult, and therefore affords security against a coup-de-main.

38. To retain the especial advantages of the Bastion Trace every part of the front must vary in the same proportion as the exterior side, whence it follows at once that very short exterior sides give low

reliefs, insignificant revetments, and feeble works. Hence Bastion Fronts are seldom made on shorter sides than 200 yards.

The improved fire-arms of the present day permit the extension of the fronts to any reasonable limits, and enable the engineer to adapt his trace more easily to the nature of the position to be fortified.

It will be a profitable study for the student to assume various heights for the escarp revetment of the enceinte, thence to deduce the minimum length of the exterior side, and then to arrange the dimensions of all other parts of the front in due proportion.

40. From the preceding paragraphs it will be clear that the dimensions of the ditch for a mean front of Vauban's first system are restricted within narrow limits. Omitting the equalization of the contents of the ramparts with the excavation of the ditch, its width and depth are determined from other principles. Thus, although it is desirable to make the ditch as wide as possible, its width must not exceed a certain limit, or the preponderance of the flank over an enemy's counter battery on the crest of the glacis at the salient point of the bastion, will be destroyed, and the escarp wall will be exposed to the breaching batteries from top to bottom. Neither must it be too narrow, or the rubbish from the breach will reach across it and form a causeway for the assaulting columns to pass over to the breach. It must not be too shallow, or escalade will be rendered easy, nor too deep or it will not be properly flanked. The standard for the depth of the ditch of a Mean Front has been fixed at 22 feet, and for the width 30 yards at the flanked angle of the bastion. Larger fronts admit of considerable deviation from these dimensions.

41. The width of the ditch, moreover, determines the minimum relief of the enceinte, for the fire from the faces of the bastions must be able to reach the foot of the glacis, clearing the heads of the defenders on the banquette of the covered way; therefore, by the principles laid down in Article 25, the minimum relief of the enceinte is immediately determined.

Whence it appears that the minimum extent of the exterior side of a Bastion Front depends upon the dimensions of the ditch, or *vice versa*, while the maximum extent is limited by the range of the fire arms used for the flanking defence.

42. Ditches are sometimes permanently wet, sometimes permanently dry, and sometimes from local circumstances can be made wet or dry at pleasure.

If a ditch be permanently wet, it can only be crossed by bridges or boats; and so long as an enemy is at a distance, the communication between the place and the outworks can be kept up with tolerable ease and security: but from the moment that he establishes himself on the crest of the glacis, his batteries command all the ditches, the bridges are swept away by his fire, and every attempt to cross must be under his view by day, or within his hearing by night. Thus the defenders are deprived of the means of succouring the outworks in the time of need; and the consequent effects upon their defence are so prejudicial, that some engineers object to permanently wet ditches, except in swampy ground, where it cannot be avoided. When a fortress has low or defective revetments, which may offer an inducement to an enterprising enemy to attempt to carry it by surprise and escalade, more particularly if the garrison be inefficient, either from the quality or number of the troops, a wet ditch serves to secure the place from a coup-de-main. Wet ditches also augment the labour of the besiegers in constructing a bridge or a causeway across them, at the end of the siege, to connect the breach to the counterscarp. If the ditches of a fortress be permanently dry, then the important object of a safe communication between the enceinte and the outworks is secured, by means of posterns and caponnieres, which give vigour to the defence, and keeps the enemy from the main enclosure as long as possible. Mining operations also can be carried on in dry ditches, to augment the duration of a siege. A fortress situated on the sea coast, or on a tidal river, may generally combine the advantages arising from wet and dry ditches. By well arranged sluices and batardeaux, the water can be excluded from the ditches, entirely or in part, so long as it is desirable to keep them dry; and when it becomes desirable to flood them, the sluices being opened during the flow of the tide allow the influx of water, and being closed so soon as the ditches are filled, the water is retained, and all the advantages of a wet ditch secured.

48. Thus the water being excluded from the ditches during the first periods of a siege, free and safe communication with the outworks is secured, so long as they are capable of defence, and in the latter periods of the siege when it becomes necessary to abandon the outworks, the ditches can be flooded with water, and the difficulty of the besiegers' last operations thereby greatly increased. Special care will be required in these cases to construct the sluices and batardeaux in

secure positions out of reach of the enemy's shot, for should they be destroyed in the early part of the siege, the ditches will become tidal and the enemy will know when they are dry and therefore passable.

44. It will be observed, that in front of the salient of each bastion there exists a large sectoral space undefended by any direct fire, and insufficiently protected by the distant fire of the flanks, which are moreover short for the purpose. To obviate this defect, and to furnish a close powerful flanking fire to the faces of the bastions, a work has been devised beyond the main ditch called the Ravelin. This work shown in Figs. 29, 30, consists of two faces of rampart and parapet, meeting in a salient angle, and provided with a ditch running into the main ditch.

In the main ditch, in front of the curtain, is frequently placed a a work called the Tenaille, also shown in Figs. 29, 30, and in front of the Tenaille a double glacis covering the passage across the ditch, called the Caponniere.

On the outer edge of the ditch, and running all round the fortress is a road, the covered way, some 20 to 30 feet in width, covered in front by a gentle sloping bank, called the Glacis.

These are the principal outworks applied to the Bastion Trace, and constitute with the body of the place what is generally called Vauban's first system. They will now be conveniently considered a little more in detail in the following order:—

The Covered Way.

The Ravelin.

The Tenaille.

The Caponniere.

45. The Covered Way (Figs. 29, 30) is usually 30 feet broad, and from having a parapet or glacis on its exterior, the crest of which is from 7½ to 9 feet in height, it affords a secure road of communication all round the fortress, outside of the ditches. Here guards and sentinels are placed, which prevent all access to the counterscarp of the ditch, to reconnoitre and sound its state or dimensions; an evil against which it is difficult to find a remedy in fortresses unprovided with a covered way, during dark and tempestuous nights. As the banquette is but 4½ feet lower than the crest of the glacis, a strong palisading is placed at the foot of the interior slope of the glacis, to prevent any attempt at forcing a passage into the covered way.

46. From the covered way, a close grazing fire of musketry is obtained upon the glacis and the surface of all the ground without. It may be considered the chief musketry position in the fortress, and being the most advanced, is defended by the weapons having the shortest range.

47. Bodies of troops can be formed in the covered way and its places of arms, to act defensively or offensively by sorties.

In a fortress without a covered way, troops for sorties or defensive purposes must be formed either within the main works when the ditch is wet, or in the ditches when they are dry: in the former case the defenders are seen by the assailant's batteries the moment they begin to double across the bridges; or in the latter, as they appear by successive files on the top of the counterscarp; consequently their regular formation is broken from the first, and the power of their attack thereby greatly diminished; and as sorties issue for a specific purpose, such as to overthrow some of the enemy's works,—to burn or destroy a part of their siege materials,—to spike their guns, &c.,—the assailant has generally time to collect a force sufficient to oblige the sortie to retreat in haste; regularity cannot then be always preserved in a way that is necessary, to check an overpowering assailant pressing on a party, that have merely narrow passages, like staircases, down the counterscarp into dry ditches, or bridges in wet, by which to retire: confusion and loss are then most likely to ensue; not to speak of the possibility of a bold rush being made to follow the sortie into the place. Whereas, in a fortress provided with a covered way, the sortie form in the various places of arms, on the fronts required; the cavalry are there ready to mount, the light artillery are horsed, the columns of infantry are regularly formed, and the working parties are provided with their entrenching tools, &c., to demolish the enemy's breast work or parapets. While the crest of the glacis is lined in every direction with light artillery and musketry, the sortie issues by the sally ports cut through the glacis obliquely or curved, so that the enemy cannot enfilade them, and immediately proceeds to the attack. The work being accomplished, the party retires in like manner, protected by the close fire of the troops within the glacis, where a secure position is at once afforded them, to face about and repel all further attempts.

48. The crest of the glacis is on an average about 8 feet above

THE OUTLINE OF A FRONT OF VAUBAN'S FIRST SYSTEM

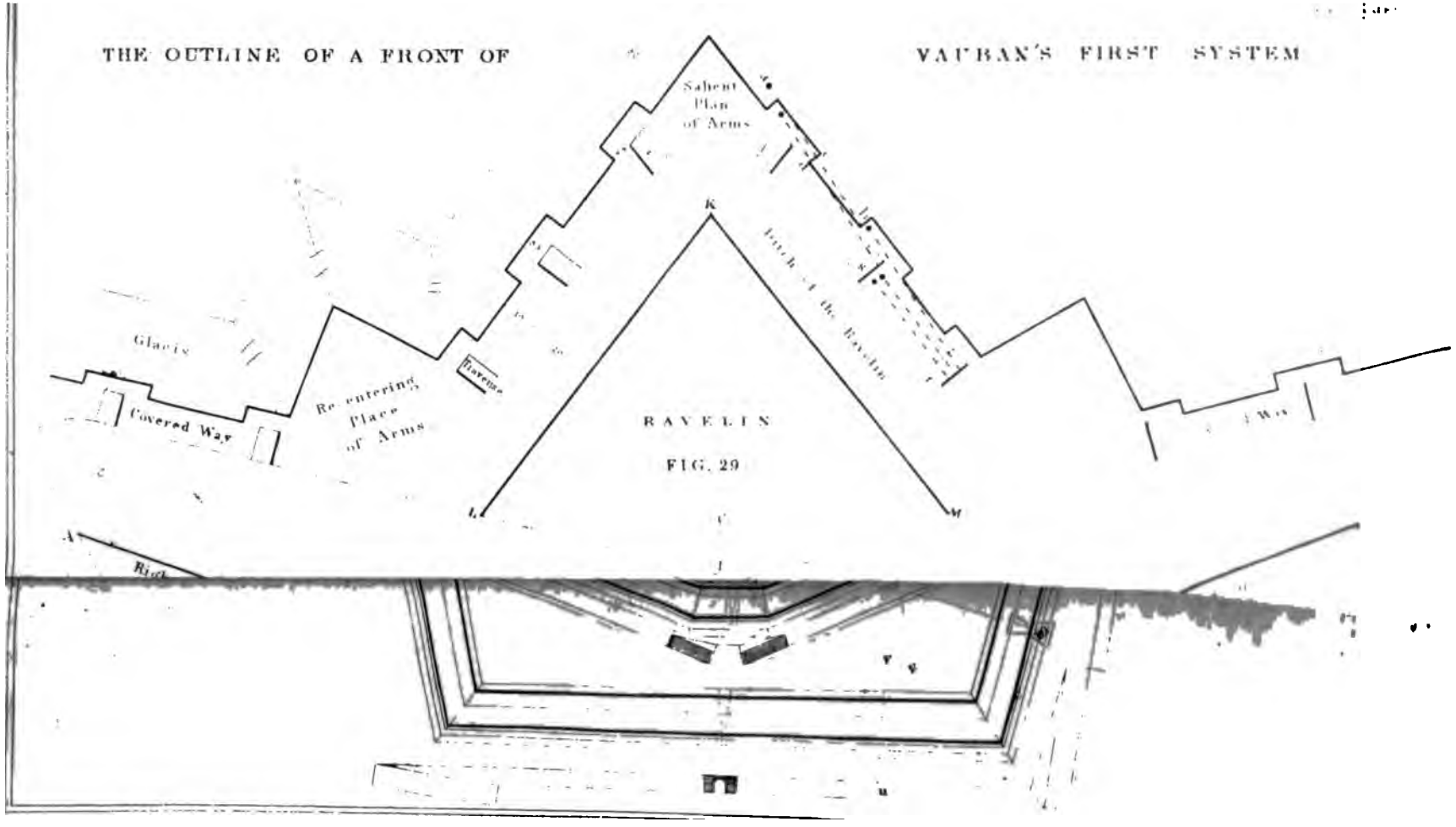


FIG. 29

the level of the ground, and as it is absolutely necessary that all the revetments of the fortress should be concealed from the view and fire of an enemy's distant batteries, the scarp revetments of the main works in its rear can be made 8 feet higher than would be possible, if there were no glacis: thus a most important result is obtained by the covered-way and glacis, in the increased height of the scarp revetment.

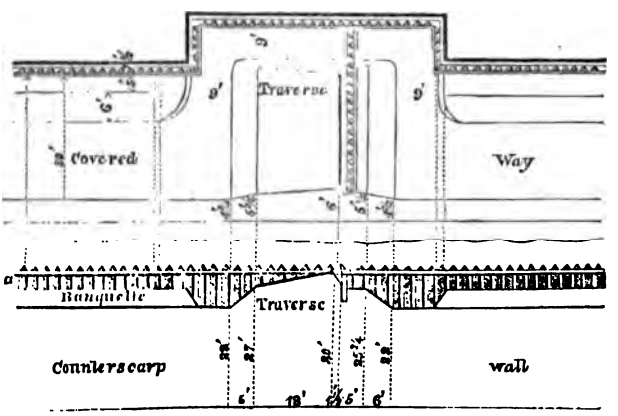
49. The glacis or exterior part of the fortification, presents to an enemy an indestructible bank, the slope being scarcely 2 inches to a yard in length, exposing therefore its whole surface and all beyond it, to the fire of works in the rear. Up this glacis the assailant must work, and must reach its crest ere he can see the revetments of the place. Here he is in a position exposed to the fire of all the remaining defences; and by his elevation, greatly interfering with, and masking the effects of, his own batteries in the rear.

50. Lastly, the covered-way being low and fully commanded by all the main-works in its rear, may be abandoned to a sudden and overpowering attack, in order that the whole fire of the other works may be brought upon the enemy within it: and when it is thus obliged to yield, there is always a hope of regaining possession of it, under the fire of the more commanding works.

51. The covered-way being a low work, is easily enfiladed and ricocheted by the enemy's batteries. To lessen the effects of this destructive fire as much as possible, traverses are thrown across its breadth at intervals of about 40 yards (figs. 29 and 30): they have their crests as high as the glacis, and are generally perpendicular to the counterscarp. These masses of earth are intended to stop the shot projected from the enfilading batteries of attack: and to do so effectually, they should never be more than 40 yards apart, that if a shot ricochets or bounds over one traverse, it may be stopped by the next. Traverses are made on the prolongations of the parapets of the faces of the bastions and ravelins, since there is no direct fire on these spots from the parapets themselves; they are also always made at the entrance of the re-entering places of arms, in order to close in these important rallying posts to the covered-way. Traverses are made to face towards the salient places of arms, as they are intended to assist in disputing the possession of the covered-way with the assailant, who in the general progress of the attack, enters the salient places of arms

first, where a fire is brought upon him from the two traverses, right and left; and should the defenders be driven from them, they retire behind the next traverses, and continue to dispute the covered-way, till they reach the re-entering places of arms.* Traverses in the covered-way are palisaded to hinder an enemy forcing himself over them (fig. 31); and a barrier-gate connects the palisades of each traverse to those of the glacis.

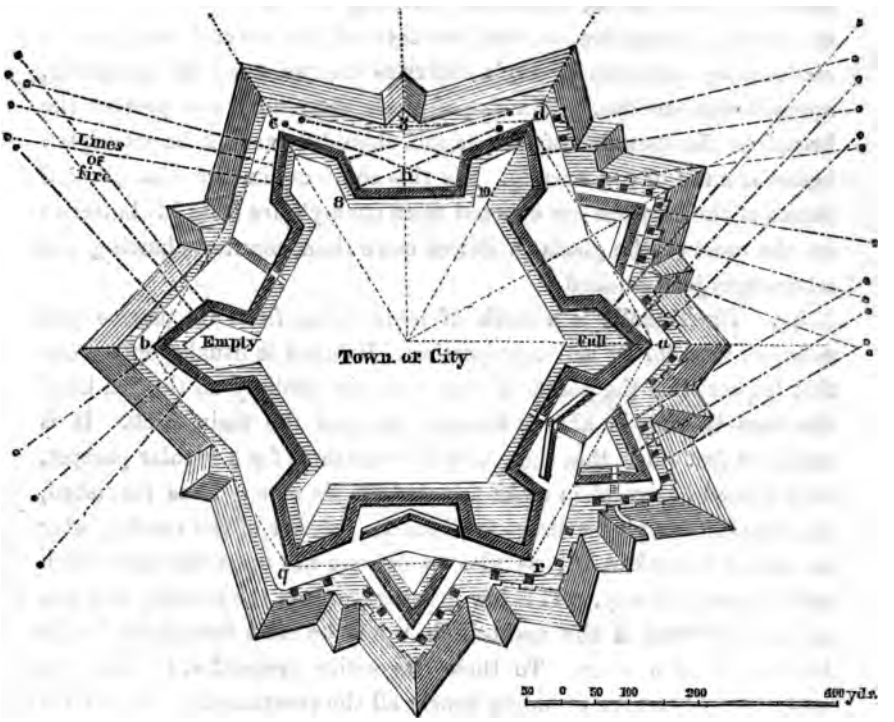
FIG. 31.



52. The Ravelin.—The relief of the ravelin is sufficient to permit it to fire over the glacis with ease, and in general it is only from 3 to 6 feet lower than the body of the place: it is, therefore, well situated for flanking by its fire all the ground on either side of it, and thus effectually defending all approach on the capitals of the bastions, by a close and powerful fire; for suppose the fronts *b c*, *c d* (fig. 32), with-

* As all the faces of the works whose prolongations fall on ground, upon which an enemy can establish himself, are subject to be enfiladed, traverses are usually constructed on them between every two guns, to neutralize the effect of this otherwise destructive fire; these, however, are not made till the siege begins and are merely passive mounds of earth, and not intended for defensive purposes, as in the covered-way.

Fig. 32.



out ravelins, the capitals of the bastions would be flanked only by the fire of light artillery and musketry, from the distant faces of the re-entering places of arms. An enemy could also establish strong batteries at the re-entering angle of the counterscarp, against the flanks of the bastions and the curtain, which position he cannot occupy on the front *a r*, where there is a ravelin, until he has got possession of the ravelin. Moreover, it covers, in a great measure, the curtains and flanks of the bastions from the fire of an enemy's batteries on the crest of the glacis, as well as from his distant batteries.—The ravelin, also, by its projection, makes a re-entering angle at the counterscarp of its ditch on each side, and thus gives the means of forming two re-entering places of arms on one front, as on *a r;* whereas, there is but one on a front without a ravelin, as *c d;* therefore, in the former case, the general outline of the covered-way is flanked by a nearer and stronger fire of musketry than in the latter.

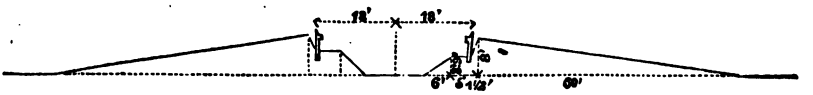
53. In some cases Vauban gave flanks to his ravelins: usually parallel to the capital, each flank carrying two or three guns capable of directing their fire on the branches of the covered-way, and of contending with the enemy's batteries on the crest of the glacis, opposite the bastions. The fire of these guns could also protect the breach in the shoulder of the bastion, should an assault be attempted before the fall of the ravelin. By this construction the shoulder and flanks of the bastions are exposed to an enemy's fire from his batteries on the crest of the glacis, a defect more than counterbalancing the advantages just detailed.

54. The Tenaille is a work of more value from its passive and relative, than for its active properties. Its crest is usually only a few feet higher than the plane of site, that the artillery on the flanks of the bastions may be able to fire over it upon the main-ditch. It is made 48 feet thick, that there may be room on it for a regular parapet, with a useful terre-plein of 12 feet wide in its rear. Thus furnished, the tenaille can give a direct fire into the interior of the ravelin, after an enemy has taken it; as also an oblique fire upon the main-ditch and the covered-way. This low grazing fire into the ravelin, and also upon the bottom of the main-ditch, would be most formidable in the latter part of a siege. To these, its active properties, it adds the important advantage of hiding nearly all the revetment of the curtain and flanks of the bastions, from the view of the enemy's batteries established on the crest of the glacis; or subsequently in the ravelin after its fall: therefore a breach fit to assault cannot be made in these parts of the enceinte, and the revetment of the face of the bastion alone is sufficiently exposed to have a practicable breach made in it. Thus then, the enemy must assault that portion of the enceinte behind which the defenders have ample space for making the best defence possible. The relief of the tenaille is usually from 24 to 26 feet: hence an enemy's battery, in a position similar to *g h*, but on the other side of the capital (fig. 30), could see over the tenaille, and beat down the upper part of the revetment of the flank *m*, as well as part of its parapet; but this would not be sufficient to form an assailable breach: for this purpose it is necessary to see to the bottom, or nearly to the bottom of the wall. Again, the mass of the tenaille is no less useful in hiding from the enemy's establishment on the covered-way, the opening or door of a vaulted passage or postern of masonry, which is indicated by the dotted lines in the centre of the

curtain in Fig. 30, and which communicates from the interior slope of the rampart, to the main-ditch. A postern is likewise pierced through the tenaille itself, also dotted, from which a protected passage, called the caponniere, leads to the gorge of the ravelin: thus a communication is kept up between the enceinte and the ravelin, a matter of the first importance in giving vigour to the defence of this latter work. Now, if there were no tenaille, as on the front *c d* (Fig. 32) the batteries of attack, on the crest of the glacis at 3, would completely command the mouth of the postern, and prevent any egress or ingress by it, the only passage from, and to, the interior of the place; a result that would be ruinous to the active defence of the outworks, and which would entirely preclude the formation of troops in the rear of the tenaille, for offensive purposes, at the latter part of the siege.

55. A Caponniere is a small glacis, usually provided with a banquette placed in a dry ditch to cover a passage across it. In Figs. 29, 30, is shown a plan, and in Fig. 33 a section of the double caponniere covering the passage from the tenaille to the ravelin in the main-ditch, of a front of Vauban's first system. The caponniere also furnishes a musketry fire on the main-ditch, and such a work is generally used to flank a cunette.

FIG. 33.
Caponniere.



56. We now come to consider the uses and value of the various parts of the enceinte. From what has already been said it may be gathered that the bastions are the most important parts of the enceinte, from their projection, position, and interior space. The whole of this first enclosure, being the last permanent obstacle the enemy has to overcome, is consequently the most formidable, having a broad ditch before it, with scarp revetments from 30 feet to 35 feet in height massive ramparts and parapets carrying the heaviest artillery, the various lines of which mutually flank each other, and by their height, overlook all the works before them. In Fig. 32, in the fronts *d a, a r*, it may be seen, by the position of the faces of the bastions, that they fully flank by their fire all the ground before the faces of the ravelins, and all the approaches by their capitals to their flanked angles, or

weak points: the ditches of the ravelins are also defended by the fire of those portions of the faces of the bastions that look upon them; and these must be silenced ere the enemy can pass the ditches thus flanked to assault the ravelin. Each flank of a bastion can carry batteries of from five to seven pieces of artillery to defend the main-ditch; and as it has been already shown that the faces of the bastions are the only parts of the enceinte in which the assailant can make practicable breaches, it is quite necessary that the ditches, by which these breaches can be reached, should be fully swept by the fire of the flanks. In a regular attack, the passage of the main-ditch cannot be effected under the fire of so strong a battery, which therefore must be silenced before the attempt can be made. The curtain may be said to have a passive rather than an active share in the defence, for it closes in the body of the place by joining the bastions to each other; nevertheless, as it overlooks the works before it, it can pour a strong fire into them after they fall into the hands of the assailant. As it has only a command of observation over the ravelin, its embrasures must be oblique to fire into the covered-way, or upon the country beyond it. Thus, in the enceinte, the faces of the bastions may be said to have the most active duties to perform: the flanks are for a specific object, viz., the defence of the main-ditch; and the curtain is nearly a passive barrier till the end of the siege, when its fire tells strongly on the works before it.

57. Defects of Vauban's first system. The bastions are contracted, the angles of defence acute, and the flanks too short to contend successfully with the enemy's counter batteries established on the crest of the glacis.

The ravelins are small and not sufficiently salient, so that except in very high polygons, the salients of the covered-way in front of the ravelins and bastions are nearly in the circumference of the same circle. Thus the enemy can crown the whole of the crest of the glacis of the fronts attacked, and establish his breaching batteries against the bastions and ravelins at the same time, so that it is possible for the enceinte to fall before the besieger has obtained possession of the ravelins. The faces of the ravelins do not spread widely enough at the gorge to cover effectually the shoulders of the bastions, so that the breaches which are made in the faces of the bastions through the openings of the ditches of the ravelins are close to the shoulders of the bastions, and uncover the guns of the flank to the enemy's enfilade.

Communication between the enceinte and outworks, at all times insecure, becomes nearly impossible after the besieger has arrived at the crest of the covered way.

58. *Construction of Vauban's first System* (Fig. 29). Make the angle of the polygon of the required opening;* and the exterior side A B, equal to 360 yards; bisect the latter by the right radius K D: on this right radius, inwards from the exterior side, lay off C D, the perpendicular, equal to one-eighth of the exterior side, for a square; one seventh for a pentagon; and one sixth for a hexagon, or polygons of a greater number of sides. From the angles of the polygon A and B, draw the lines of defence through D, the inner extremity of the perpendicular; and on these lines, lay off two-sevenths of the exterior side from the angles of the polygon, for the faces of the bastions; these points G H, mark the shoulder angles of the bastions. From each angle, A and B, of the polygon, as a centre, with a radius extending to the furthest shoulder angle, describe arcs intersecting the lines of defence; chords to these arcs give the flanks of the bastions G F, H E; and a line joining the inner extremities of the flanks will give the curtain E F.

59. To trace the main ditch, describe an arc of a circle from the flanked angle of each bastion, with a radius of 30 yards when the ditch is dry, and 36 yards when it is wet; lines drawn as tangents to these arcs from the shoulder angles of the collateral bastions, give the counterscarp.

60. To trace the ravelin, set off for the capital 100 yards I K from the re-entering angle of the counterscarp I, of the main ditch, along the right radius, in order to fix K, the flanked angle of the ravelin; from this point K, the faces are directed to points at 10 yards from the shoulder angles of the bastions in the rear, taken along the faces. The ditch of the ravelin is 20 yards wide; the counterscarp being drawn parallel to the escarp.

61. The faces of the tenaille coincide with those parts of the lines of defence that lie between the flanks of the bastions: its thickness is 16 yards; its extremities or profiles, are parallel to the flanks of the bastions, at a distance of 8 yards; and its rear is parallel to the curtain at 10 yards.

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* The number of degrees in an angle of a regular polygon of n sides is equal to $\frac{2n-4}{n}.90°$

62. To trace the caponniere, draw its crest parallel to the perpendicular at 6 yards; and its glacis at 20 yards parallel to its crest; the passage between the demi-gorge of the ravelin and the head of the caponniere is 3 yards wide.

63. The breadth of the covered way is 10 yards, following the windings of the counterscarps of the ditches. At the re-entering angles, set off 30 yards on each side, as demi-gorges for the place of arms; at these points the faces are to form angles of 100° with the original tracing of the covered-way. The foot of the glacis is parallel to its crest at 50 yards.

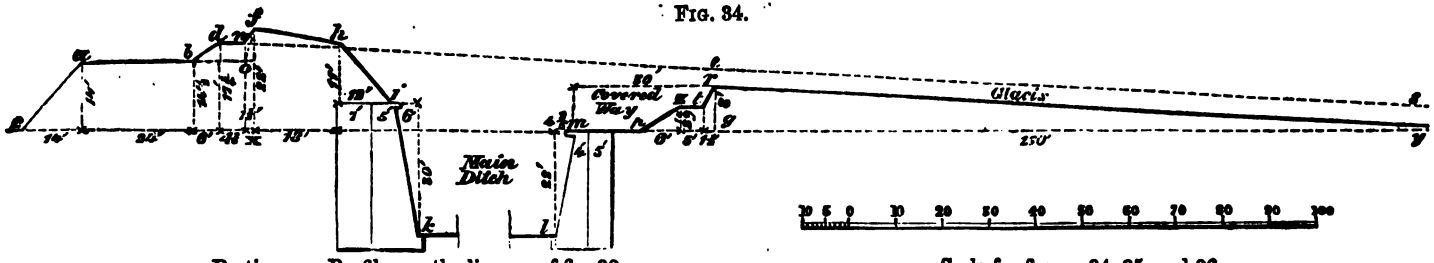
64. The superior slopes of the traverses are 18 feet thick. The traverses at the salient places of arms are formed on the prolongation of the faces of the ravelins and bastions; those at the re-entering places of arms, are perpendicular to the covered way. Each branch of the covered way before the ravelin, has a third traverse, placed midway between the salient and the re-entering places of arms. The dimensions of the passages round the traverses are marked on the plan (Fig. 29). When all the slopes are in, there should be a space of 9 feet clear, all round the traverses.

65. To construct a set of profiles to this system, the reader is referred to Figs. 34 and 35, which represent sections taken on the lines *u v*, *v x*, *x y*, *y z*, of Fig. 30, and by which it may be seen that the

	Feet.
Command of the enceinte over the country is - -	22
„ „ over the ravelin - -	8
„ „ over the crest of the glacis -	14
„ „ over the tenaille - -	20
The command of the ravelin over the crest of the glacis	11
The crest of the glacis above the ground - - -	8
The depth of the main ditch below the level of the ground is - - - - - - - -	22
The depth of the ditch of the ravelin ditto - - -	22

66. The staircases at the salient places of arms before the bastion are 36 feet in length, and 6 feet in breadth; those at the re-entering places of arms are of like dimensions (*see* Figs. 37 and 38); but before the ravelins, where the space between the traverses is more limited, the staircases may be made, either like those before the bastion, but shorter, or as seen before the ravelin in Fig 30; having a length of 36 feet, and a breadth of 9 feet. Those at the gorge of the ravelin

FIG. 34.



Bastion. Profiles on the line *n s* of fig. 30. Scale for figures 34, 35, and 36.

FIG. 35.

Curtain. Tenaille. Profiles on the lines *u v*, *v x*, *x y*, *y z*. Ravelin. Covered-way.

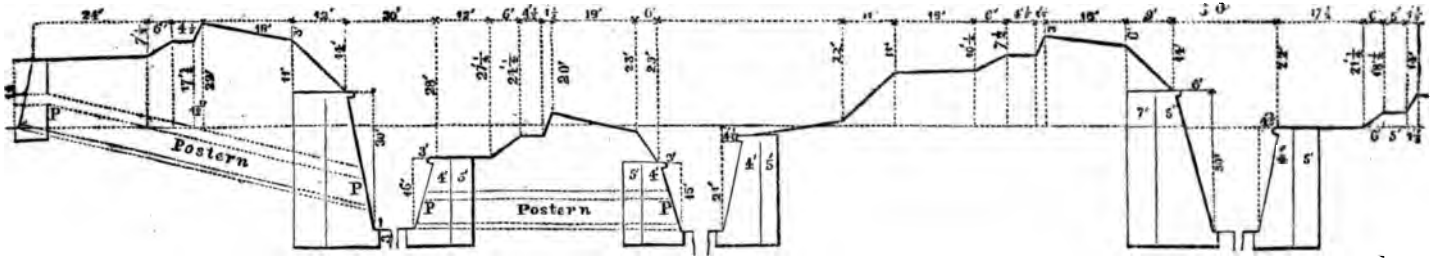
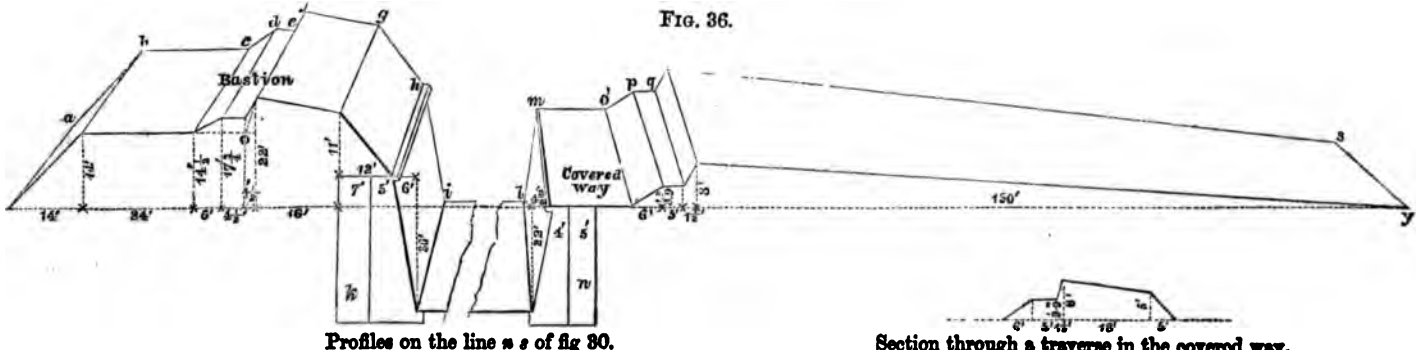
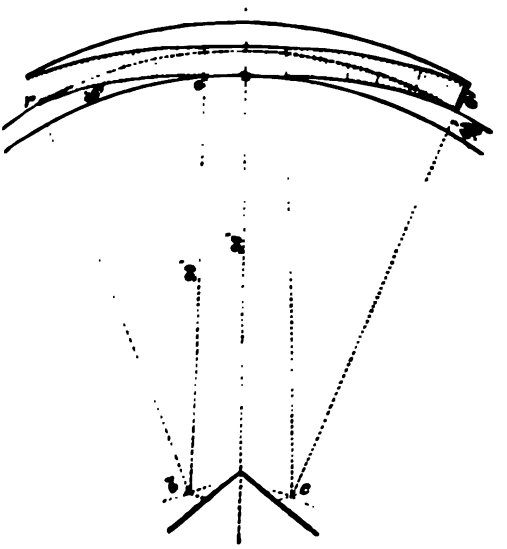


FIG. 36.



Profiles on the line *n s* of fig 30. Section through a traverse in the covered way.

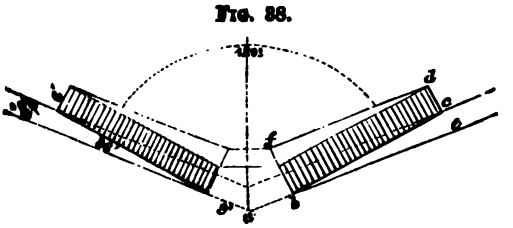
FIG. 37.



Staircase before the Bastion at the Salient Place of Arms.

Scale for both Figures, 40 feet to an inch.

FIG. 38.



Staircases at the Re-entering Place of Arms.

are 36 feet long, and 6 feet wide; and at the gorge of the tenaille, 30 feet long, and 6 feet wide, in shape like those at the re-entering place of arms.

67. The ramp at the gorge of a full bastion, as well as at the flank of an empty bastion, is 36 yards long, and 6 yards wide. The ramp along the interior slopes of the rampart of the ravelin is 20 yards long, and 4 yards wide, the construction of these ramps is shown in Figs. 39, 40.

The barbettes and embrasures are omitted in Fig. 30, in order to keep the plan as simple and clear as possible.

FIG. 39.

Ramps at the Gorge of a Full Bastion.

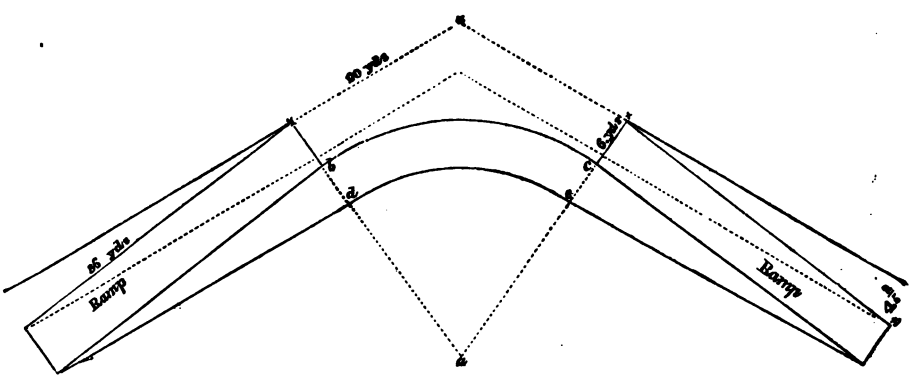
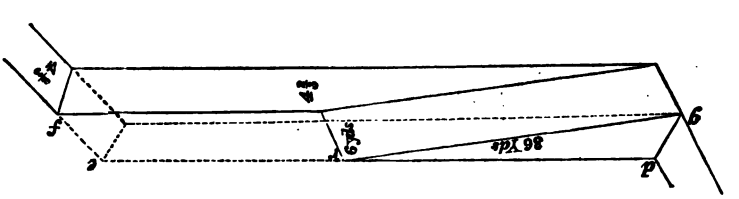


FIG. 40.

Ramp at the Flank of an Empty Bastion.



Scale for both Figures, 20 yards to an inch.

CHAPTER III.

DEFECTS OF VAUBAN'S FIRST SYSTEM.—COUNTERGUARDS, CHEMIN DES RONDES.—RETRENCHMENTS.—MODERN SYSTEM.—DUFOUR'S IMPROVEMENTS.

68. In the simple bastion trace, described in the last chapter, under the designation of Vauban's 1st system, it is immediately apparent, that from the moment when, in the ordinary process of a siege, the assailant has completed his lodgment on the crest of the glacis, the whole of the escarp revetments of the ravelins and bastions are exposed to his view, and that through the opening of the ditch of the ravelin he can see the escarp of the face of the bastion, in the neighbourhood of the shoulder angle to its very foot: he places his guns in battery on the crest of the glacis, he keeps up a continuous and heavy fire on certain selected spots of the escarp wall, which some 15 or 24 hours will generally bring tumbling in fragments into the ditch. The mass of rampart and parapet, having now lost the support of the revetment, rapidly follows its fall, forming a practicable breach, that is a continuous slope of moderately easy ascent from the bottom of the ditch to the interior of the place, forcing the garrison to the inevitable alternative of immediately surrendering or enduring the peril of an assault.

Two defects are here manifest:—1st, The facility of breaching the escarp wall, 2nd, the inevitable surrender of the place on the formation of a practicable breach. For these defects two remedies are needed. 1st, to delay and increase the difficulties attendant on the formation of a breach; 2nd, to devise means for continuing the defence after the formation of a practicable breach. Of these objects the former is generally attained by the use of counterguards, the latter by the construction of retrenchments, works which will now be considered.

69. A Counterguard is a rampart and parapet constructed in the ditch, in front of the face of a bastion or ravelin, usually consisting of two faces forming a salient angle, as indicated by the shaded portions in the diagram. Counterguards are expressly constructed to cover the escarp walls and delay, if not prevent the formation of breaches, they should therefore be as high or nearly so, as the revetments they cover, and so thick as not to be easily destroyed. They may be, and frequently are in dry ditches, revetted all round; they are then expensive and are liable to be readily breached, though when this has been effected as far as possible, the rubbish

FIG. 41.

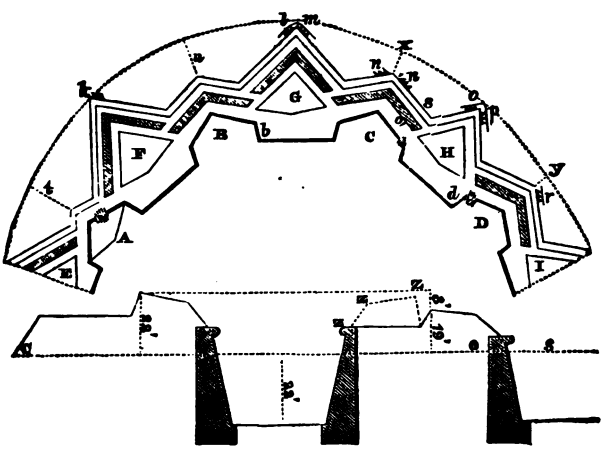


FIG. 42.

remaining from the destruction of the counterguard, affords a valuable protection to the escarp.

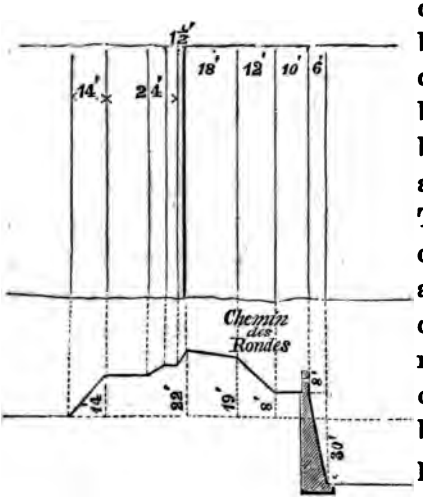
Counterguards, especially in wet ditches, may, and frequently do, have no revetments, their interior and exterior slopes are then continued, with the usual depression of 1 in 1 to the bottom of the ditch. They are much less expensive, more difficult to breach, but occupy more space than revetted counterguards; and it may be objected that, in dry ditches, they are readily stormed, a matter of little moment since they could never be held under the close and commanding fire of the work immediately behind.

When a work is well covered by a counterguard, it is generally necessary for an assailant to obtain possession of the counterguard,

and there erect his battery to breach the escarp; to make this operation as difficult as possible, the counterguard should be as narrow as other considerations will allow. A thickness of 50 feet will admit of a shot proof parapet and leave room enough for the working of guns behind it: and although this space is sufficient for all defensive purposes, yet it is too limited for an enemy to establish himself upon: for example, if he were in possession of the work *o*, he is exposed to the full fire of the faces of the bastion C, to shield himself from which, he has to construct a parapet upon the side of the counterscarp, which involves in it the transfer of the original parapet from the scarp to the gorge side of the work, as indicated by the dotted lines *z z z*, Fig. 42. The object of a counterguard is to cover the work before which it is placed; so that an enemy must beat it down, and raise it almost to its foundation, ere he can see the main work in its rear sufficiently to breach it.——A counterguard before a bastion, as *o*, covers the faces of the latter from the view of the enemy's batteries on the opposite crest of the glacis, as from *n n*; and shields the flanks *d* and *b*, of the collateral bastions, from the enemy's counter-batteries *n* and *n*; so that, to breach the faces of the latter, or to silence the batteries of the flanks that defend these faces, the counterguards must be quite destroyed. These two great advantages are somewhat neutralised by the effects of the tracing, by which the salient places of arms before the bastions and ravelins are brought into nearly the same circumference of a circle, so that the enemy arrives at these three points *x o y*, and establishes his batteries there, at the same time, while from those at *o p*, he sees through the ditches of the ravelin, and can still breach the shoulder-angles of the adjoining bastions, and turn all the retrenchments between the shoulder and the flanked angle.——Now, in examining the tracing of the counterguards before the ravelins F and E, it will be seen, that the salient place of arms before the bastion is thrown into a deep reentering space *t*. To establish himself here, an enemy would have great difficulty, as he would be seen, not only in flank, but even in reverse, from the salients of the adjoining counterguards. It may then be fairly calculated, that the two counterguards before the adjoining ravelins must be silenced before a satisfactory establishment can be made by an enemy on the crest of the covered-way of the bastion between them; but from the narrowness and

position of these counterguards, immediately under the fire of the ravelins, it would be almost impossible to prevent the defenders returning from time to time to man them, unless they were actually possessed as well as silenced: and to possess them, to the exclusion of the besieged, it would be necessary to capture the ravelins that so closely defend them. The figure also shows that an enemy at *k*, on the salient before the counterguard of a ravelin cannot breach the face of the bastion near the shoulder-angle, but only half way up the face, so that the retrenchment made in the upper part of the bastion cannot be turned till after the fall of the ravelin.——The conclusion to be drawn from these remarks is, that fronts having counterguards before bastions, and others having counterguards before ravelins, have respectively good properties; although the latter construction gives greater defensive advantages, by producing great salient and deep re-entering angles in the general outline.—— The effects of counterguards before both bastions and ravelins are shown in bastions B C, and ravelin G, where the enceinte is entirely hidden from the enemy's establishment upon the covered-way. Counterguards have, in some cases, been continued in connection, before both ravelins and bastions, so as to form a complete envelope to the enceinte and ravelins; but such a construction, like the redan tracing, gives dead angles which can only be defended by casemated guns.

Fig. 43.



70. Chemin-des-Rondes.—The difficulties of forming a practicable breach are very considerably increased by the construction of a broad berm, some 8 or 10 feet wide, between the top of the escarp wall and the foot of the exterior slope. This work derives its name from one of the purposes to which it is applied, namely, to enable the officers on duty at night to go their rounds, to observe the ditch and covered-way more closely than can be done from behind a thick parapet; passages or posterns are made

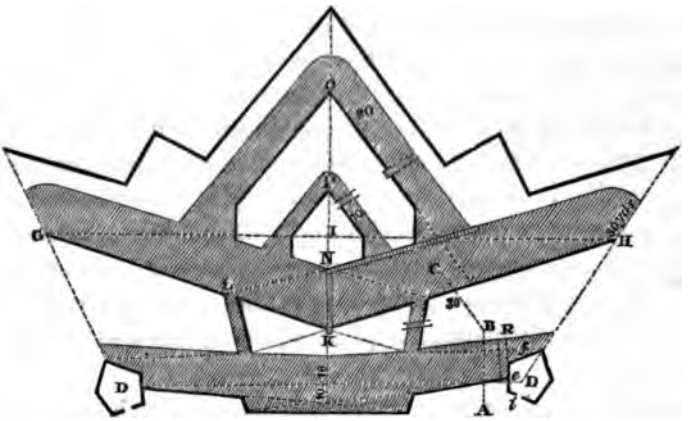
at convenient places, through the parapets, to lead from the terre-plein of the rampart to the Chemin-des-rondes. Besides permitting a more minute examination and a stricter guard to be kept, this form of construction has also the following advantages:—1st. It permits the defenders to come out to repel an escalade with their bayonets, from the most advantageous position; whereas, in the common form of parapet resting on the exterior revetment wall, they are placed behind thick parapets, over half of which their fixed bayonets cannot reach. 2nd. If a breach be made in the revetment, its fall does not immediately entail that of the parapet above, as in the common construction, and a practicable breach is, therefore, more difficult to form. For suppose the wall that supports the mass of the rampart to be battered down, the rubbish would leave a rough slope nearly parallel to the exterior slope of the parapet; and the quantity of parapet that would fall in consequence, would depend upon the height of the revetment, and the breadth of the Chemin-des-rondes. The broader the latter is made, the less of the parapet would fall. 3rd. As the defensive efforts at the moment of assault should be seconded by throwing live shells, grenades, and combustibles into the ditch, this can be much more effectually done from the top of the scarp wall on the Chemin-des-rondes, than from behind thick parapets. For the shell, in rolling over the ordinary parapet, receives a direction and impetus that causes it to fall into the ditch in a curve, within which the assailants are mounting, and are, therefore, comparatively safe. 4th. A thin wall of masonry, from 4 to 8 feet high, may be built upon the exterior edge of the scarp revetment, which, by augmenting the height of the revetment (already supposed to be 30 feet high) renders escalade almost impossible. This wall may be loop-holed for musketry. It is true that nearly all this small wall can be seen from the enemy's batteries, because it is above the plane of defilade of the crest of the glacis, and can, therefore, be beaten down by their fire long before an assault takes place: but this destruction of the wall is only on the two or three fronts commanded and enveloped by the enemy's attack. The other parts of the fortress, which must be always strictly watched during a siege, are rendered much more secure against an enterprise or escalade, by this additional height of scarp. The Chemin-des-rondes is nevertheless objected to by some writers: 1st. Because it affords a good space for an escalading or storming party to form upon, after overcoming the revetment; and

by it to pass round the exterior slope of the parapet, to enter the work at any part, and thus turn or get in the rear of any interior retrenchments, intended to cut off the breach and prolong the defence. 2nd. Because the interior space of a work having a Chemin-des-rondes is diminished by the parapet being thrown in 10 feet all round. With regard to these two objections, it is admitted, that the second is quite just: but it can never stand in the way of the many advantages already stated as belonging to this work. The first is a more serious one; but it is presumed, that by means of cuts across the Chemin-des-rondes, and obstacles planted on it, the enemy might readily be prevented from circulating, at pleasure, round the work to turn the retrenchments.

In conclusion, it is to be remarked, that although differing materially, as do the modern French and German engineers in their tracings and constructions, they appear agreed on the value and importance of the covered berm for riflemen; it is seen in Carnot's system, and in the recent construction for the defence of Paris. In the Prussian system, nearly the whole of the faces of the ravelins have berms or Chemin-des-rondes with loop-holed walls: and in the German works of Fort Alexander, near Coblentz, the same arrangement is found.

71. In a properly arranged fortress on the bastion system, certain limited portions only of the escarp are liable to be breached from an enemy's batteries on the crest of the glacis. These portions are the faces of the ravelins and bastions near to the salient angles. If a single line of rampart and parapet forms the only defence at these places, a practicable breach completely exposes the interior to the enemy, and compels the garrison to capitulate at once, or to undergo all the horrors of an attack by storm. In most cases interior works can be made, separating the parts liable to be breached from the remainder, and thus enabling the defenders to hold out, after the formation of a practicable breach, so as to prolong the duration of the siege, or to obtain more favourable terms of surrender. Such works are especially important, and take the name of retrenchments. In the simple tracing already described as Vauban's 1st system no retrenchments are shown; but in his later constructions Vauban acknowledging the necessity for retrenchments of a permanent nature; retrenched his ravelins by furnishing them with redoubts, and his bastions by detaching them, and separating them by a ditch from the enceinte.

Fig. 44.



This arrangement is shown in the annexed diagram. The faces of the bastion are the only portions of the enceinte that can have practicable breaches made in them; and it is of the first importance to prepare such defences in the bastions attacked, as shall prolong the struggle as much as possible. But as it cannot be known on what fronts the attack will be made, the construction of retrenchments is usually deferred till the period of the siege; and, therefore, are merely works hastily thrown up. When it is considered that a well-conducted powerful attack will conquer a good front in twenty-five or thirty days at most, and that, during this period, the whole energy of the garrison is successively concentrated on the most pressing demands of the defence, it is evident that the formation of retrenchments should be attended with as little labour as possible.

72. A bastion provided with a cavalier is easily retrenched; especially if the cavalier have a ditch on its face (Fig. 45); for then a cut or small ditch made across the terre-plein, and through the parapet of each face of the bastion, in rear of the breach, will isolate it at once; and

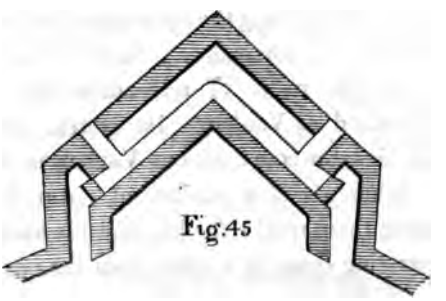


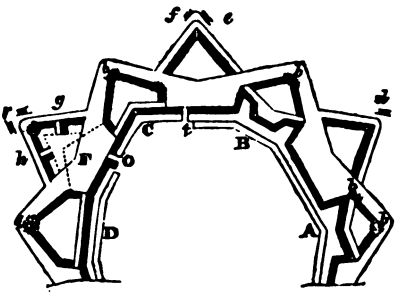
Fig.45

this cut or coupure having a parapet within it, facing the breach, will enable the defenders to bring a fire upon the summit of the breach, from behind these obstacles. For a complete cavalier retrenchment, *see* that made in the centre bastion of the modern system, Fig. 48, and more clearly shown in Fig. 52. It will be observed here, that the coupure is not cut through the scarp revetment* of the face of the bastion, although it is necessary for it to go through the thickness of the parapet: for, if the parapet were left uncut, the assailants might, on gaining the summit of the breach, turn the retrenchment, by mounting and passing along the top of the parapet. Were the coupure cut through the scarp revetment, it would lower the wall by several feet, and not only offer a diminished height of revetment, as an inducement to an enemy to escalade, but give him a view of the ditch of the coupure: and, through it, of the revetment of the face of the cavalier, from the crowning of the covered way. The coupure should be flanked by the fire of the face of the cavalier, although this is not always easy from the great command of the latter. That the ditch of the cavalier may not be without defence, there is a parapet formed, carrying one or two guns, retired about 21 feet in rear of the coupure; nevertheless, there will still remain a dead angle in it. The parapet of the coupure is also provided with an embrasure for a gun, to flank the terre-plein of the face of the bastion immediately before it. When the ravelins are large, as in Fig. 48, where their faces, prolonged, fall upon the bastions at 34 yards from the shoulder angles, this cavalier retrenchment answers very well; since an enemy, established upon the crest of the covered-way, before the ravelin, and firing through its ditch, cannot breach the space behind the coupure: but such a construction in a system with small ravelins would not answer: for example, in Fig. 30, the enemy's batteries q q', could turn every retrenchment between the shoulder angle and the flanked angle of the bastion, by firing through the ditch of the ravelin.

73. Full bastions are preferable to empty ones, as far as offering more facilities for forming retrenchments, from their large elevated terre-pleins allowing of the construction of works to command the summit of the breach. In the following modes of retrenching, the bastion is considered to be *full*. Here b b b b (Fig. 46) are supposed

* The wall at this point is formed to an angle at top, to prevent its being used as a passage to turn the retrenchment.

FIG. 46.

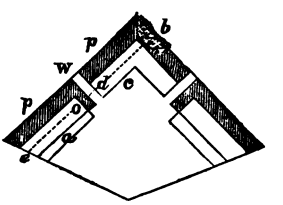


to be breaches made by an enemy's batteries from the crest of the glacis. Bastion A shows the form of a simple retrenchment, which, from its shape, is called a tenaille retrenchment; being a parapet and ditch, drawn from each shoulder angle inwards. The ditch has no flanking defence; a defect which may be in part rectified by constructing, if there be time, a small front with faces and flanks, as seen in bastion B. The crest of the parapet of such a retrenchment, should be equal in height to that of the work before it; and it should have a good field profile: the ditch of this retrenchment is always cut through the parapet, but not through the revetment, for reasons already stated in the last paragraph. Both these retrenchments cut up much of the valuable interior space, cramp the defensive efforts, and interfere with the active service of the bastion. Those portions of the parapets and ditches of the retrenchments that unite the shoulder angles, should not be finished till near the time of assault, that there may be as much free use of the bastion as possible. Should an assailant have pushed his attack to the crest of the glacis, and have established batteries, as *r f e d*, to enable him to fire through the ditches of the ravelins, it is evident, that he can breach the shoulder angles of the bastions, when the ravelins are small, as seen in the figure: and thus the retrenchments in bastions A and B would be turned, and become useless. They are, therefore, inapplicable to fronts having small ravelins. Bastion D is a gorge retrenchment; it gives a more free use of the bastion than the two foregoing methods, and is more easily constructed. The extremities may be completed at the very last, and the ditch opened through the scarp revetments, that it may receive a flanking defence from the artillery of the flanks of the adjoining bastions: this defence, except on very high polygons, is very oblique. A more direct flanking defence can be obtained by making the retrenchment as in bastion C, upon the prolongation of the adjoining curtains. In these retrenchments, posterns may be made under the parapets with mining cases. Another, and a more common method of communication is by narrow cuts through the parapets and slight bridges over the ditches, defended

by traverses, and covered in front by a little stockade, loop-holed for musketry.——Every means should be adopted to render the retrenchment formidable: if the ditches be unflanked, their sides should meet at an angle at the bottom; or, the bottom should be so narrow as not to admit of a resting place for a formation on it. Chevaux-de-frize, iron crows'-feet, harrows, &c., should be fixed in the ditch and on its sides, and, if possible, upon the summit and on the sides of the breach itself. Small mines should be prepared to blow away the rubbish of the breach at the moment of assault, so as to make it difficult, and, if possible, impracticable to mount; mines should be formed to blow away the whole mass of the breach on the assailants gaining its summit; and small mines or fougasses to aid in the defence of the retrenchment: there should also be an abundant supply of grenades, live shells, and combustibles, to shower into the ditch at the moment of assault.

74. If the bastion be empty or hollow, it can be retrenched by coupures, as shown in Fig. 47. By examining this diagram, where the breach is shown at *b*, it can be seen that *a* is the interior slope of the rampart, which is suppressed or cut away perpendicularly between the coupure and the flanked angle. The rampart is here retained by a strong timber stockade *c*, so that the assaulting party rushing up the breach *b*, cannot descend at the part *c*, but are exposed to the fire of the parapets of the coupures. The portion *p p* is the parapet; *w* indicates the top of the revetment wall of the bastion; *d* is the ditch of the coupure, which may be deepened if required; *o* is the parapet of the retrenchment. Should the retaining stockade or wall *c*, not be thought sufficiently high to deter an enemy from attempting to descend, a ditch may be cut at the bottom, of such a depth as will prevent him from doing so. ——Even after the retrenchment in the bastion has been forced, measures should be prepared for prolonging the defence. Supposing the gorge retrenchment of the bastion C to be forced, let coupures (as seen at *o* and *t* in Fig. 46) be made across the terre-plein of the neighbouring curtains, having the interior slope of the rampart between them cut away perpendicularly, and the houses looking into the gorge loop-holed for musketry.——This last observation leads to the consideration of disposing the houses in the neighbourhood of the

Fig. 47.



attacked bastion, to assist in the defence: which is to be done by barricading the streets leading to the breach, and loop-holing the several stages or stories of the houses for a musketry fire. Some remarkable instances of a prolonged resistance are on record in connexion with countries where the houses were of solid construction, and the inhabitants interested in the defence, such as that of Saragossa, in Spain, the defence of which lasted from the 20th December, 1809, to the 20th of February, 1810; the latter twenty-three days was a war of streets and houses.

75. Ravelins should also be retrenched; but as they are never made full as are bastions, the mode of doing so is the same as has just been described for empty bastions (Fig. 47), and as seen in ravelin F, where the coupures, *h* and *g*, are directed upon the flanks of the adjoining bastions, from which their ditches could be defended. Every ravelin, however, would be the better for a permanent redoubt within it, which Vauban rarely omitted; and which, in Cormontaigne's and the modern systems, is carried to its full extent. If nothing better can be had, a common loop-holed wall, or good stockade will cover the staircase at the gorge: it will enable the defenders to bring a fire of musketry upon the breach, and allow of a deliberate retreat being made: such a wall, 2 feet thick, being incapable of resisting the fire of cannon, should be always lower than the parapet before it, that it may be screened from the enemy's view. Ravelins having redoubts can be still further retrenched, as in the modern system (Fig. 48), where the salient part of the work is cut off by coupures. These are so traced as to fall within the redoubt of the covered-way, that they may not be seen in flank, nor the revetment wall exposed to be battered from the crowning of the covered-way.——To retrench the covered-way, in which there is no regular redoubt, a parapet and ditch may be made, having two faces forming a salient angle. The re-entering place of arms affords the best space for the formation of a retrenchment: moreover, the staircases are thus covered and secured. If there be not time to form an earthen parapet and good ditch, a loop-holed stockade with a ditch in front should be constructed. In the modern system (Fig. 48) there are good permanent revetted redoubts in the re-entering places of arms. Salient places of arms can also have good stockades or loop-holed walls to cover their staircases; but their position is not so favourable as the re-entering places of arms.

76. The German engineers, in their recent constructions discard the bastion tracing, and obtain a flanking defence for the ditches on a totally different plan. The bastion tracing is still approved, and retained by the French, who have brought it, perhaps, in the modern system, to a state as nearly perfect as the nature of the tracing admits. In the modern system, many modifications of, and improvements on, the 1st system of Vauban are apparent, in comparison with which the bastions are more capacious, and can be more perfectly and more readily retrenched. The faces are more extended and can receive a greater number of guns. The flanks are longer, and can more effectually cope with the enemy's counter-batteries established on the crest of the glacis. The angles of defence are right angles, and the ditch more directly defended. The ravelins are furnished with redoubts and coupure retrenchments; they are too, far more salient, so that the besieger must capture two ravelins with their retrenchments and redoubts, before he can crown the crest of the glacis, in front of the salient of the intermediate bastion. The faces of the ravelins spread more to the rear, and their ditches are furnished with caponnieres, which partially cover the escarps of the bastions, so that the breaches which are made in the faces of the bastions, through the openings of the ditch of the ravelins are much more difficult to make, and when made, are much further distant from the shoulder angles. They can therefore be more easily retrenched, and do not uncover the guns on the flank to the enemy's enfilade, so long as the redoubts remain in the hands of the defenders. Their flanks furnish a strong fire on the breaches in the faces of the bastions.

The faces of the ravelin may be considered a counterguard which must be taken and destroyed before the enemy can breach the escarp of its redoubt; and the faces of the bastions again act as counterguards to the cavaliers. Every part liable to be breached, or taken by storm, is effectually separated from the remainder by a complete system of permanent retrenchments; the covered-way by the redoubts in the re-entering places of arms; the ravelins by coupures in the faces, and by their redoubts; the bastions by coupures, and by cavaliers; so that a number of works are presented to the enemy, which he must overcome in succession, and by each of which his progress is retarded, and the duration of the siege extended.

The strong redoubts in the re-entering places of arms cover and

protect the assembly and issue of sorties from the places of arms, and add greatly to the security of the covered-way by flanking closely its adjoining branches on either side.

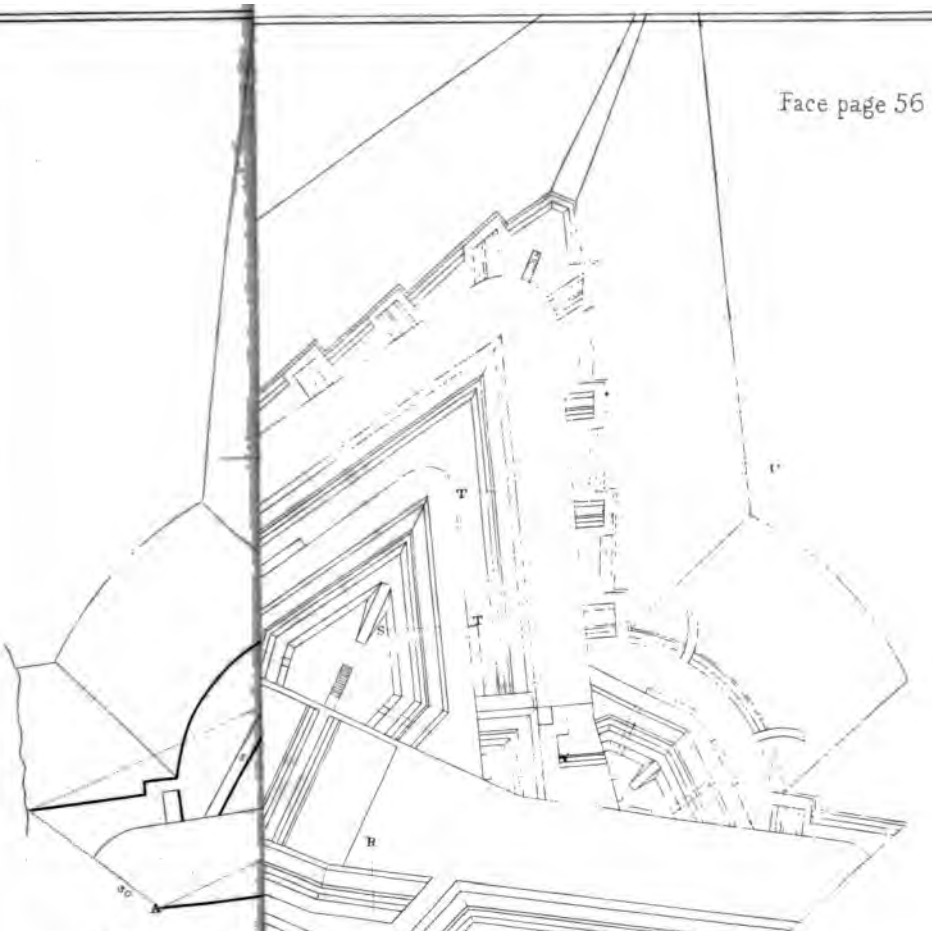
The different levels of the ditches, together with the caponnieres in the main ditch and in the ditches of the ravelins, cover the communications and allow greater freedom of access between the enceinte and outworks, while they are brought more completely under the fire of the works defending them.

77. The great defect of liability to enfilade, inseparable from all systems on the bastion trace still remains, though for high polygons it is in some measure palliated. The faces of the ravelins and of their redoubts and the flanks of the bastions are as open to enfilade as the same works in Vauban's 1st system. The faces of the bastions are in some measure protected in octagons and polygons of a greater number of sides by the great saliency of the ravelins.

There can be little doubt that with rifled guns of such accuracy and range as are now coming rapidly into use, enfilade will be practised with a precision and from a distance vastly greater than has been hitherto attempted, and it will be a question whether any gun on an open rampart will remain undisabled for a day. This being the case, there can be no doubt but that all guns of fortresses must sooner or later be placed in casemates, where they are entirely secure from enfilade fire. This is even now being partially carried out, and in the proposed new works for the fortification of Antwerp, the guns on all the faces liable to enfilade are provided with casemated cover. The construction of, and difficulties attending the adoption of casemates, will be considered in a subsequent chapter.

It must be borne in mind that great as these improvements undoubtedly are, they are attained only by great additional expense.

78. *Construction of the Modern System, or Cormontaigne's improved system—on an octagon* (*see* fig. 48). Make the angle of the polygon of the required opening; in the present case, for an octagon, 135°; make the exterior side of the polygon A B 360 yards; one-sixth of which gives the perpendicular C D; the faces of the bastions being one-third of the exterior side. The flanks are perpendicular to the lines of defence upon which they fall, making the angles of defence right angles. The main ditch is 30 yards wide at the flanked angles; and the counterscarp is drawn to the shoulder of the parapet of the next bastion. For the ravelin, set off 34 yards from the shoulder



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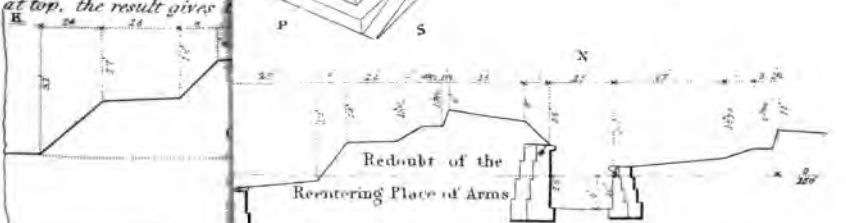
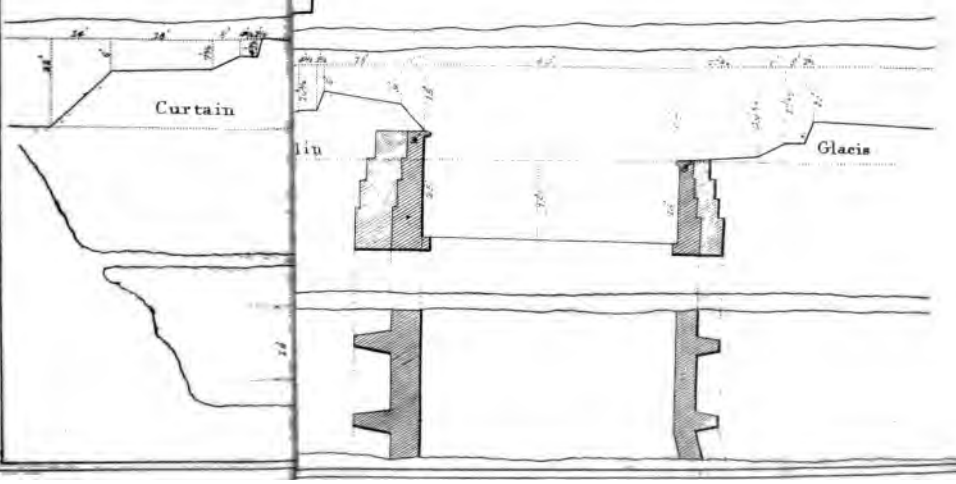




angle of each bastion, along the face; the line joining these points gives the base of the equilateral triangle F G H, having its vertex on the right radius, for the flanked angle of the ravelin: its ditch is 20 yards broad, rounded before the salient angle. The face of the redoubt of the ravelin is drawn parallel to that of the ravelin from the shoulder angle of the parapet of the bastion; its ditch is 10 yards wide, which leaves the ravelin 21 yards thick. Divide this thickness at its extremity into two parts, and join the points of division for the gorge both of the redoubt and of the ravelin. This redoubt has flanks: they are traced by setting off 16 yards along the gorge, and with a radius of 18 yards from thence, cutting the face; a line joining these points gives the flank. The Tenaille is of the usual thickness of 16 yards, and the revetments being perpendicular in this system, its profile is only 5 yards from the flank of the bastion: the main-ditch in rear of the tenaille is 10 yards wide. The Caponniere is of the same dimensions as in the first system of Vauban, running up to within 9 feet of the gorge of the redoubt of the ravelin. To obtain the cavalier, draw the faces and flanks parallel to the cordon or magistral of the bastion, at a distance of 24 yards: on the faces, these lines will show the counterscarp of the ditch of the cavalier; and on the flanks, the foot of the exterior slope of the parapet. The ditch, on the faces, is 10 yards wide, drawn inwards from the counterscarp; there is no ditch on the flanks, which are 28 yards in length from the shoulder angle of the cavalier. For the coupure, or cavalier retrenchment, raise perpendiculars to the faces of the bastions, from the points marked 34 yards from the shoulder angles, for the counterscarps of the coupures; the scarps are 10 yards within and parallel to them. Behind this short scarp, there is a parapet, with one embrasure for the defence of the terre-plein before it. The ditch of the cavalier is defended by a parapet retired from the coupure by 7 yards, having two embrasures, to trace which, draw a line from the flanked angle of the cavalier through the point where the scarp of the coupure cuts the counterscarp of the ditch of the cavalier; this will determine its length. For the covered-way trace the crest of the glacis at 10 yards parallel to the general outline of the counterscarp. For the redoubt in the re-entering place of arms bisect the re-entering angle of the counterscarp of the covered-way by a capital; join the flanked angles of the bastion and ravelin together, as A G; and the portion of this line intercepted between the capital and the counterscarp of the main-ditch gives one face of the counter-

scarp of the ditch of the redoubt; the other is drawn from the angle of the salient place of arms before the bastion, through the flanked angle of the ditch of the redoubt, till it meets the counterscarp of the ditch of the ravelin. The scarp is 5 yards parallel within these lines. This redoubt has a flank of 6 yards in length at the end of its parapet, on the side adjoining the ravelin; and here its demi-gorge is formed by a line drawn from the flanked angle of the ravelin through the inner extremity of its flank, by which a small triangular space is added to the ditch of the ravelin, as seen in the plan, whereby another gun may be brought to bear up the ditch from the face of the bastion. For the crest of the re-entering place of arms, set off 15 yards from the extremity of the counterscarp of this redoubt, along the counterscarp of the ditch of the ravelin, and with a radius extending to this point, from the original re-entering angle of the counterscarp, as a centre, describe a curve outwards. The superior slope of the traverses, at the entrance of the re-entering place of arms is 6 yards thick. On the branches before the ravelin, there are three other traverses, with superior slopes of 3 yards thick. The passages are en crémaillère or single crotchet (*see* fig. 53). The crest of the parapet at the salient place of arms is cut off perpendicularly to its capital, to give a banquette of 6 yards, for the purpose of obtaining a direct fire upon the ground before the capital. In order to obtain the coupure or retrenchment in the ravelin, let fall a perpendicular from the extremity of the escarp of the redoubt in the re-entering place of arms, through the face of the ravelin. This line crossing the ravelin gives the counterscarp of the ditch of the coupure. The scarp is 15 feet parallel within it, having a parapet behind it to bring a fire upon the terre-plein of the ravelin.

The ramps or sally-ports leading from the re-entering place of arms, through the glacis, are 4 yards wide, and are of a curved outline to prevent their being enfiladed. The counterscarp of the redoubt in the re-entering place of arms, is descended by a ramp opposite each face, 12 yards long and 3 yards wide, and 5 yards from the salient angle. Posterns, 6 feet wide, are formed under the rampart, to lead from the interior into the ditch opposite the ramps. Staircases, 6 feet wide, are drawn at the salient and re-entering places of arms, parallel to the counterscarp. Ramps, 20 yards long and 4 yards wide, lead from the ravelin to the ditch of its redoubt; and a staircase communicates from this ditch into the space behind the coupure of the ravelin. A postern leads from the ditch of the redoubt of the ravelin, through

the middle of the flank, into its interior. A staircase, 9 feet wide, leads from the main-ditch at the head of the caponniere into the redoubt of the ravelin. Posterns, as in Vauban's first system, communicate from the interior of the place through the curtain into the main-ditch; and also through the tenaille. The usual ramps are formed in the interior slopes of the ramparts of the enceinte (*see* Fig. 48), in the redoubt of the ravelin, and in the re-entering place of arms. Barbettes of suitable dimensions are made at the flanked angles of the works. The faces of the bastions and ravelins, as well as those of the cavalier, are armed with artillery, having traverses between every two guns. Figures 49, 50, and 51, contain the profiles to the above system, by referring to which, all further requisite information will be obtained; and by referring to Figs. 52 and 53, the formation and disposition of the embrasures and barbettes of bastion and ravelin will be seen and comprehended.

79. By the foregoing construction, it is seen—1st, That the ravelin is made as large and salient as possible; the flanked angle being reduced to its minimum, viz., 60°, by which the salients before the bastions are thrown into re-entering spaces, and an enemy finds difficulty in crowning the salients before the ravelins and bastions at the same time. This is an advantage which increases with the opening of the angle of the polygon; for suppose, in Fig. 48, that the two fronts were moveable upon the point B, then, by opening the angle of the polygon, the salients before the ravelins would be thrown continually forward, while the salient before the bastion remains almost stationary, and becomes more and more re-entering in proportion to the opening of this angle; so that on a very high polygon, it would be quite impossible for an enemy to crown the glacis before the bastions and ravelins at the same time, for the great saliency of the ravelins permits the defenders to take all the ground around the crest of the salients of the bastions, both in flank and reverse, and thereby totally prevents the establishment of batteries there, until the ravelins are reduced. Now, the redoubts within the ravelins are so entirely parts of the ravelins, that the reduction of the redoubts cannot be effected without the reduction of the ravelins. Hence, to crown the covered-way before a bastion in a high polygon, requires the reduction of four strong pieces. The attack then becomes complicated and prolonged, and it is necessary to keep the re-entering places of arms in check while the attack is going on against the ravelins and their redoubts,

by running a fourth parallel across the ridges and slopes of the glacis. The batteries established against the ravelins on the crowning of the glacis, by firing through the ditches, in order to counterbatter and to silence the guns on the faces of the bastions that flank the ditches of the ravelins, obtain a complete command of these ditches, so as to enable the miners of the assailant to penetrate the mass of the ravelin, in order to bring it down. Breaching batteries are also prepared on the glacis at the same time as the counterbatteries, in order to breach the faces, and to enfilade the terre-pleins, so as to dismantle or ruin the parapets of the coupures.

The besiegers' mines under the ravelin bring down the whole mass of it, including the counterscarp of its redoubt, so as to leave the flanked angle fully exposed to be breached from the crowning of the covered-way, without the additional labour of forming batteries within the ravelin for the purpose of breaching it. While the latter proceedings are going on, the usual operations are carried up the glacis towards the crest of the salient place of arms before the bastion. The redoubt within the re-entering place of arms having been turned by the reduction of the ravelin, gives, by its great elevation, a considerable protection to the assailant.

2nd. The thickness of the ravelin is 68 feet, which is 15 feet more than Vauban allowed for his counterguards, and which, therefore, requires considerable efforts on the part of the besiegers to level. It is still narrow for them to use as a position for a lodgment.

3rd. The value of the ravelin is increased by cuts or coupures near the extremity of each face, which serve as retrenchments. By the tracing, it may be seen (Fig. 48) that the counterscarp of the ditch of this small retrenchment falls upon the extremity of the escarp of the re-entering place of arms, and therefore cannot be enfiladed. These coupures keep the enemy at the salients of the ravelin, and prevent him from turning the redoubts in the re-entering places of arms. These coupures must, therefore, be reduced, not only on this account, but to prevent them from interrupting the proceedings of the assailant in the ditches, both in front and in rear of the ravelin. The coupures screen the postern door on the flank of the ravelin.

4th. By the construction, the gorge of the redoubt of the ravelin is parallel to, and within, the exterior side of the polygon. It is, therefore, concealed by the flanked angles of the adjoining bastions from every part of the enemy's establishment on the crest of the

glacis. The staircases and passage at the head of the caponniere are thus rendered perfectly secure.

5th. The flanks of the redoubts of the ravelin are sufficiently spacious to carry three guns each, and these bear upon the positions in which breaches can be made in the adjoining bastions; and as they cannot be reached by a counter battery, on account of their situation, it becomes necessary to reduce them. The guns in these flanks may be casemated, by which their security would be considerably increased.

6th. The passages round the traverses in the covered-way are made en crémaillère (single crochet), an arrangement affording less cover than the double crochet of Vauban's 1st system, to parties of the assailants storming the covered-way, each passage being fully enfiladed by the fire of the traverse next behind. The traverses on the long branches of the covered-way are only 9 feet thick,—solid enough to parry the effects of the besiegers' enfilade, and too thin to withstand the close fire of the heavy guns of the place, by which they can be speedily destroyed, to prevent an enemy using them for cover on his gaining possession of the covered-way.

A passage 4 feet in width is usually made round the inner side of the traverse (between the counterscarp and the traverse), by which the defenders can retire with more security than by the wider passage on the side of the glacis. These passages are all closed by barrier gates connected with the palisading of the traverses.

The re-entering place of arms is sufficiently capacious to contain a substantial revetted redoubt. Its crest is a circular arc, partly securing it from the effects of enfilade fire. Sally ports are cut from it, sloping upwards to the glacis, in such a manner that they may be free from an enemy's enfilade. These ramps, or sally-ports, are frequently made in the form of circular arcs.

7th. The redoubt in the re-entering place of arms has, by the construction, one face clear of enfilade; the other would also be difficult to enfilade, especially in high polygons. The ditch of the face looking towards the ravelin is flanked: the other is not,—a defect quite inadmissible in permanent works.

This redoubt, by its great elevation, it has the same command as the ravelin (16 feet) over the country, performs an important part in the defence, and is therefore furnished with a narrow rampart for field artillery. It adds materially to the defence of the covered-way, serving as a strong retrenchment, and renders an attack "de vive

force" impracticable. It covers the prolongations of the flanks of the bastions. It is provided with a flank bearing upon the position where a breach could be formed near the salient of the ravelin. A line drawn through the salient of the ravelin and the extremity of this flank determines the gorge, a construction by which its staircases are secured from enfilade, and another gun from the bastion brought to bear on the ditch of the ravelin.

8th. A remarkable feature in the system is that the command of the ravelin and of the redoubt in the re-entering place of arms is the same—16 feet over the country—both having a command of fire over the crest of the glacis, and both submitted by 6 feet to the enceinte. In the opinion of many engineers, the relief of this redoubt is too great. It greatly interferes with the fire from the faces of the bastions, especially at the latter part of the siege, when the third parallel and the saps around it cannot be seen from the faces of the bastions.

9th. The crest of the glacis is 11 feet above the plane of site at the re-entering places of arms, and 9 feet at the salient places of arms before the ravelins. The terre-plein of the covered-way has a similar inclination, rising 2 feet between the salient in front of the ravelin and the re-entering place of arms: apparently a faulty construction, greatly assisting the besieger in selecting positions for his enfilading batteries, and exposing to his enfilade fire the branches of the covered-way.

10th. The revetments are well covered. The lower part of the crest of the glacis is 9 feet, and the highest part of the scarp revetment is 7 feet above the plane of site.

11th. The communications between the various parts of the system are by posterns, caponnieres, ramps, and staircases. A postern under the centre of the curtain, with a depression of 1 in 8, leads from the interior of the place to the main ditch, its opening being 6 feet above the bottom of the ditch as a security against surprise. This postern is continued through the tenaille, and a caponniere completes the communication across the ditch to the gorge of the ravelin. This caponniere is generally described as open, but it is strongly recommended to form a covered passage through it, of masonry strongly arched, in continuation of the postern, to prevent the interruption of communication, which necessarily occurs with open caponnieres immediately the besiegers have established themselves on the crest of the glacis. Passages, 9 or 10 feet in width, between the caponnieres and the gorge

of the ravelin, give access to the ditch. Staircases 6 feet in width, at the gorge of the redoubt of the ravelin, form the communication between its interior and the main ditch. A postern under each flank gives access to the ditch of the redoubt. From this ditch a ramp on each face leads up the terre-plein of the ravelin, and a staircase into the coupure retrenchment. Staircases communicate between the main ditch and the redoubts in the re-entering places of arms, posterns pass under their ramparts to their ditches. From these ditches ramps ascend to the terre-plein of the re-entering places of arms, and through them to the branches of the covered-way.

Whenever practicable it is recommended to substitute earthen ramps for masonry staircases. The latter become soon destroyed by the besiegers' shells, and cannot readily be repaired. The former are less liable to injury, and when injured are far more easily restored.

FIG. 52.

Details of the Bastion and Cavalier of the MODERN SYSTEM.

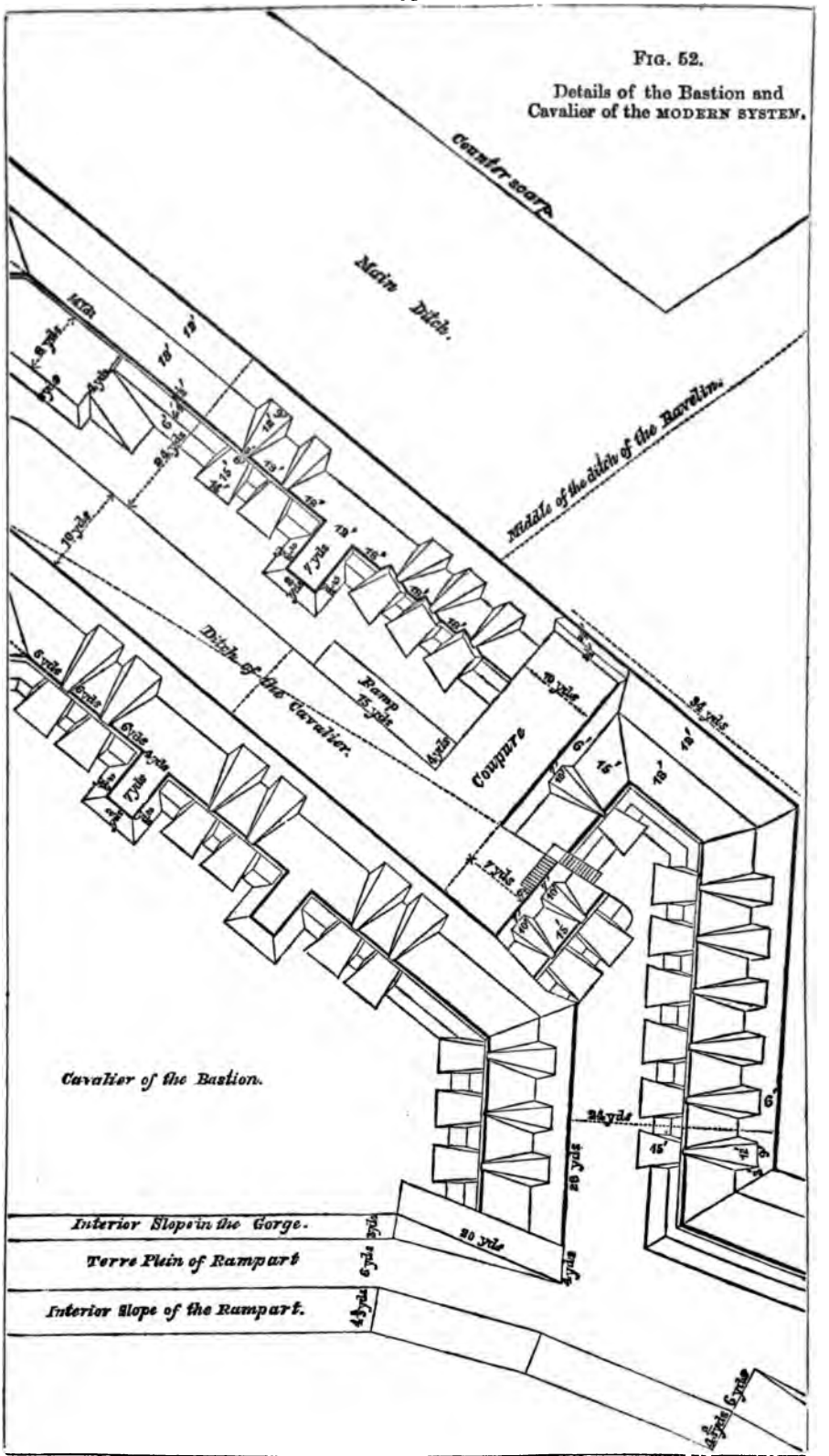
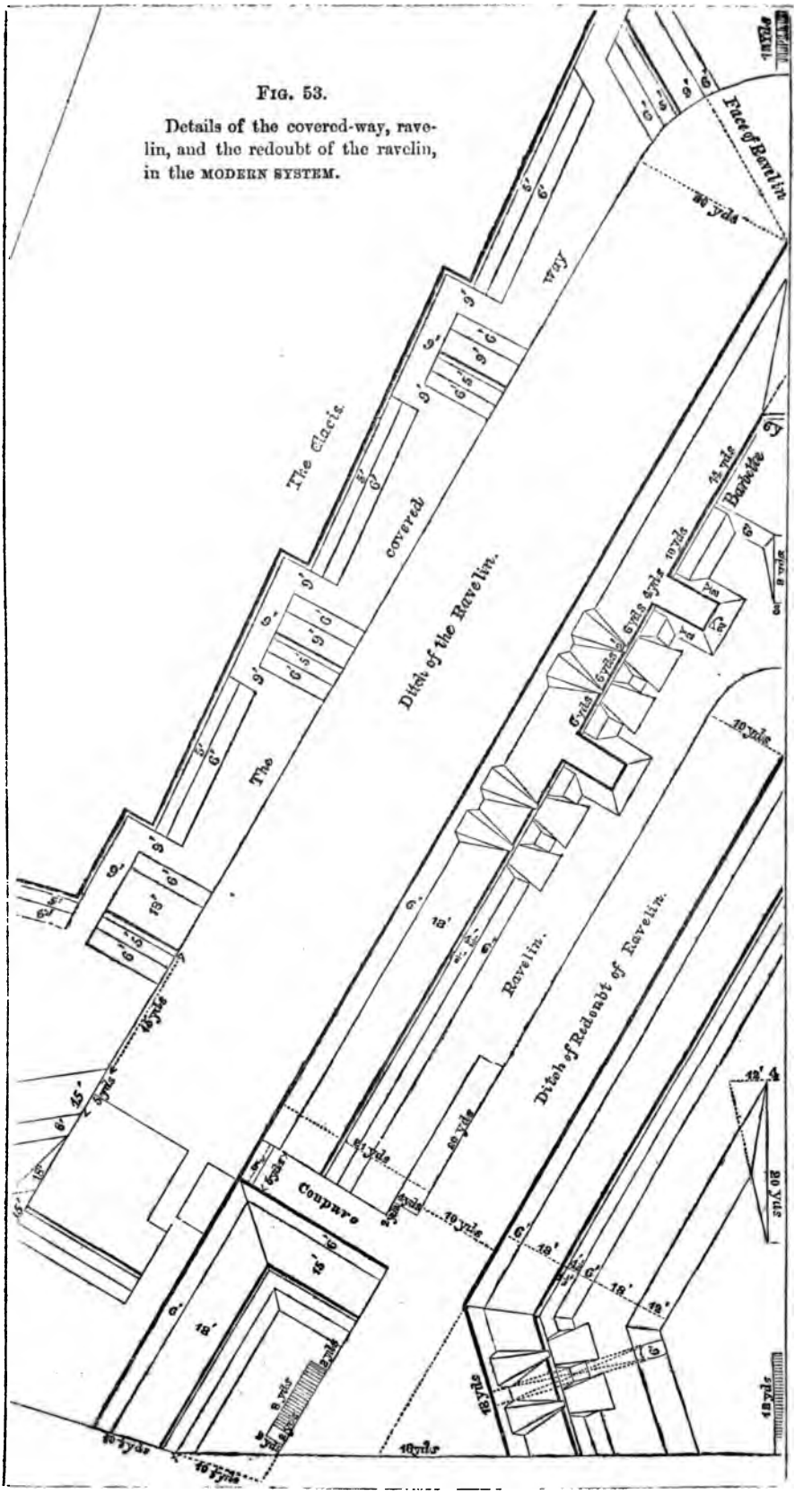


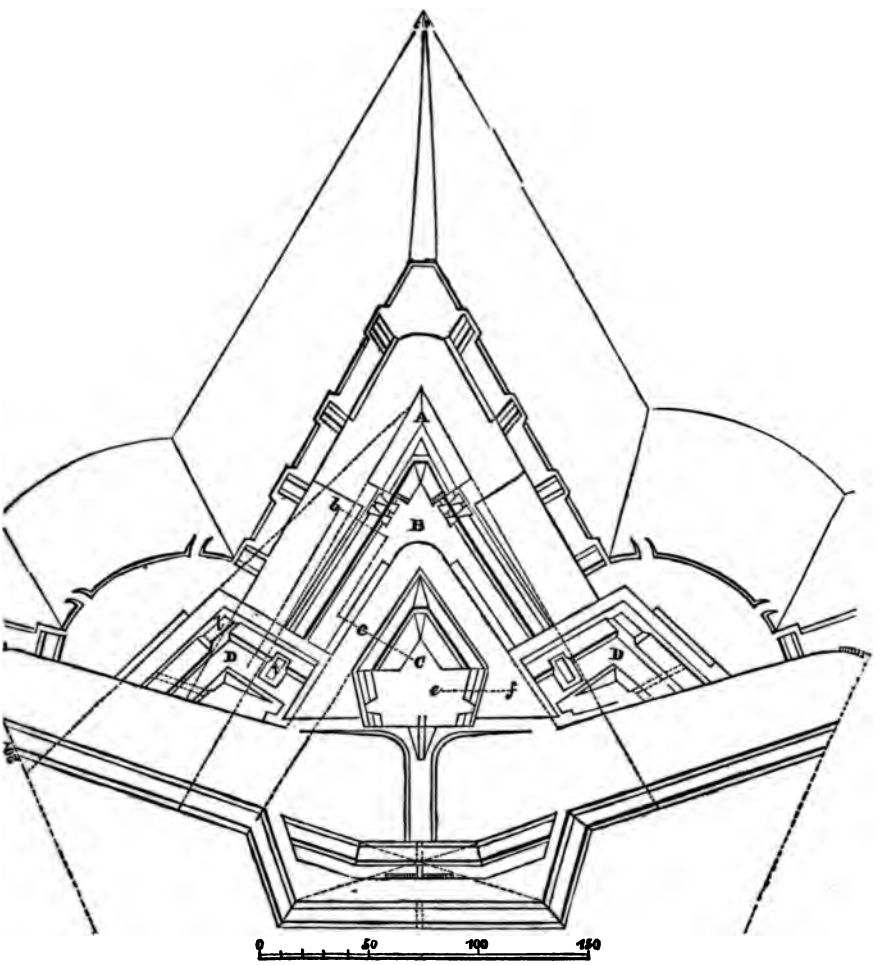
FIG. 53.

Details of the covered-way, ravelin, and the redoubt of the ravelin, in the MODERN SYSTEM.



80. Dufour's modifications of Cormontaigne's System (Figs. 54, 55, 56). Trace the outlines of the enceinte and ravelin as in the

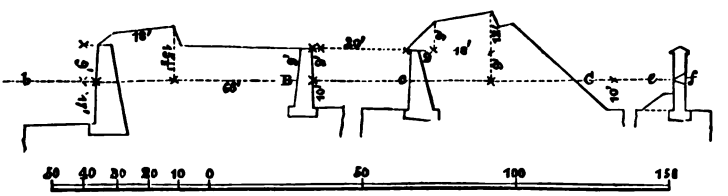
FIG. 54.



modern system. From the salient of the ravelin, along each face, lay off 45 yards, and from these points raise perpendiculars inwards, each equal to 8 yards. Join the extremities of these perpendiculars with the original rear extremities of the faces of the ravelin for the escarp of the new faces of the ravelin. At the salient of the ravelin is an elevated mass A, raised 44 feet above the plane of site, so as to screen entirely the faces of the ravelin from enfilade fire. The faces of the

redoubt of the ravelin C, are drawn from the shoulder angle of the parapet of the bastion, parallel to the faces of the ravelin. This work has a parapet on its faces, but its flanks, which are 25 yards long, are merely loopholed walls with a banquette, having in each a gateway wide enough for artillery. The redoubt of the re-entering place of arms D, is constructed in a manner which Dufour considers a great improvement. The outer face is drawn from the flanked angle of the ravelin to a point 20 yards along the capital of the bastion. The

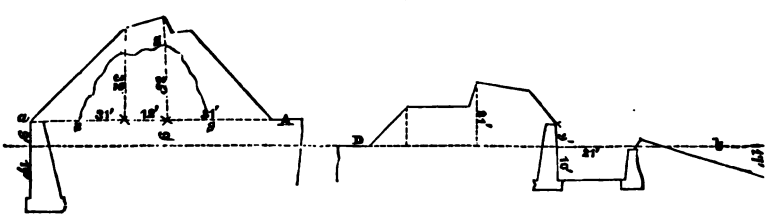
FIG. 55.



Scale for Figs. 55 and 56.

inner face is made perpendicular to the face of the redoubt of the ravelin, from its shoulder angle. Thus the trouée of the ditch of the ravelin is closed, so that the faces of the bastion cannot be seen from the crowning of the covered way. The outer face is protected from enfilade, by the elevated mass of the cavalier of the ravelin. The inner face is furnished with a bonnette *l*, at the salient, and a traverse *t*,

FIG. 56.



upon the prolongation of the parapet of the ravelin, to shelter it from enfilade; this bonnette and traverse are each 8 feet higher than the parapet.—The covered way is like that in the modern system. The communications are by good broad ramps and posterns.—The cavalier of the ravelin is made of large loose stones, having a covering of only 2 feet of earth, so as to render a lodgment upon it by an enemy impracticable.

Dufour's objects in these modifications are evident. The cavalier of the ravelin A, is to shelter the faces from enfilade fire. The redoubts in the re-entering places of arms have certainly the advantages that he proposes, for no breach can be made from the crowning of the covered way, in the faces of the bastions through the ditches of the ravelins; and the counterscarps of these redoubts are covered by a glacis in the ditches of the ravelin, as may be seen in Fig. 56, on the line D *b*, which is a section taken in Fig. 54, on the line with the corresponding letters.—In the redoubt of the ravelin there is no terre plein, the slope of the banquette being continued to a level 10 feet below the plane of site, so that an enemy, should he gain possession of this work, can find no space on which to form a lodgment.

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CHAPTER IV.

THE ATTACK.

81. An army about to undertake the siege of a fortress must have the superiority in the field; that is, it must outnumber the garrison, together with any force that may be likely to come to its aid, or it will be liable to have its operations disturbed and interrupted, to the great advantage of the besieged and risk of the besiegers.

The besieging army will commence its operations by investing the fortress; that is, it will advance with the greatest secrecy and rapidity, and occupy positions on every side, to cut off all communication with the adjacent country, and confine the garrison entirely to their own resources. The positions thus occupied are strengthened by field-works, and a sure communication is kept up between them.

It is absolutely necessary to invest the fortress attacked, so as to prevent the garrison holding any intercourse with the neighbouring country; for if this precaution be not taken, the defenders will be able to draw fresh supplies of men, provisions, and ammunition from the country, increasing greatly the duration of the siege, and reducing the chances of ultimate success. The late siege of Sebastopol is a memorable instance of the truth of these remarks. From the nature of the ground, intersected by the inlet of the harbour of Sebastopol, and from the insufficiency of their force, the allied army was unable to complete the investment. Thus the fortress on the northern side was left open to receive all the reinforcements of men and materiel which could be furnished by the resources of Russia. Fresh officers, fresh troops, fresh provisions were continually poured in; the defences were enlarged and multiplied; and the besiegers, attacked in their own lines, held at one period a very critical position. Thus the

siege was prolonged beyond that of any other of modern times, and success was ultimately attained by a loss of men and materiel, and by a force of artillery altogether unprecedented. Ground was broken on the 10th October, 1854, and on the 10th September, 1855, the Russians, having sunk their ships, retreated from the southern to the northern side of the harbour. The fortress thus fell into the hands of the Allies exactly eleven months after the commencement of their attack.

A place may sometimes be reduced by investment or blockade alone, and where it is possible suddenly to blockade a place ill provisioned and filled with a numerous garrison and population, it may be the most ready and bloodless mode of proceeding. Indeed, many other circumstances may render it desirable to endeavour to reduce a place by blockade.

When the defenders have been driven within their works, and the place invested, the ground before the fronts to be attacked is carefully examined, and the most suitable situations selected for the park of artillery, and the engineer's park: the former to receive all the ordnance stores and ammunition; the latter all the engineers' stores and materials to be used in the construction of the trenches, batteries, &c. These parks should be placed in secure localities, behind the slopes of hills or in ravines, beyond the general range of the guns of the fortress, but with a ready access to the trenches and batteries of attack, for the use of which they are formed.

82. The artillery and engineer parks having been duly established, and an adequate supply of ordnance, ammunition, and materials collected in them, for a week's or ten days' consumption, the actual works of the siege begin. The objects of the besieged are three.

1st. By a superior fire of artillery to dismount the guns and subdue the artillery fire of the place.

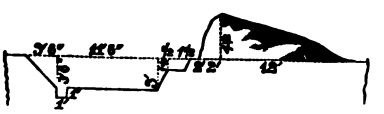
2nd. To construct a secure and covered road by which his columns may march to assault the defensive works, so soon as they are sufficiently destroyed to justify the attempt.

3rd. To breach or batter down the escarp revetments of the fortress in certain spots, causing the fall of the rampart and parapet supported by them, and thus exposing the interior of the place to the assaulting columns.

83. Now, before any means can be taken to attain any one of these objects, a strong force must be placed under cover, close at hand to

the spots on which the necessary operations are to be commenced, whose duty it is to repel any sortie of the enemy, and drive back any parties which issue from the place to destroy or interrupt the works of the Attack. The cover provided for this guard of the trenches is usually a trench and parapet of a profile, shown in the annexed diagram.

Fig. 58.



First Parallel.

This trench, called the First Parallel, is formed around the whole of the fronts attacked; and, consequently, frequently attains an extensive development: its distance from the advanced works has usually been between 600 and 700 yards. In the late siege of Sebastopol, the First Parallel was opened at a distance of 1,200 yards; and doubtless, in future sieges, owing to the increased range of firearms, the First Parallel will seldom be less, and may probably be considerably more distant. This Parallel is formed by approaching the place secretly in the night with a body of men; part carrying entrenching tools, and the remainder armed. The former dig a trench in the ground parallel to the fortifications to be attacked, and with the earth excavated from the trench raise a bank on the side next the enemy, while the latter remain under arms, usually in a recumbent posture, in readiness to protect the working party, should the garrison sally out. During the night, this trench and bank are made of sufficient depth and extent to cover from the missiles of the place the number of men requisite to cope with the garrison, and the besiegers remain in the trench throughout the following day, in despite of the fire or of the sorties of the besieged. This trench is afterwards progressively widened and deepened, and the bank of earth raised till it forms a covered road, called a Parallel, embracing all the fortifications to be attacked; and along this road, guns, waggons, and men securely and conveniently move, equally sheltered from the view and the missiles of the garrison. So soon as the First Parallel is established, the engineers select positions for the batteries to silence the defensive artillery. In the posi-

tions of these batteries lies one of the principal advantages of the besiegers.

84. Batteries of guns and mortars are now constructed a little in advance of this parallel, in positions, such that their guns enfilade all the faces of the works attached. See batteries I. to IX. Fig. 57.

The crest lines of these batteries are therefore made perpendicular to the prolongations of the faces of the ravelins and bastions of the fronts attacked, and so great is the advantage to the besieger arising from such positions of his batteries, that with an equal or sometimes smaller number of guns he is able speedily to subdue the artillery fire of the defence. These enfilading batteries on the first parallel should be completed and ready to open fire on the third morning after breaking ground.

85. After the fire of the defensive artillery has been sufficiently subdued, the approaches are commenced. These, like the first parallel, are trenches dug in the ground and protected by a parapet formed of the excavated earth, thrown up on the side of the enemy's works. The approaches are made on the capitals of the ravelins and bastions attacked, but not in a straight line directly towards the salients, as in that case they could be enfiladed from end to end, but in a zigzag direction, alternately to the right and to the left of the capitals, in such a manner that their prolongations fall clear of the fortress, and the possibility of enfilading them is entirely removed.

The heads of these approaches are pushed forward by small parties of men, who, from their great numerical inferiority, are quite unable to contend with sorties issuing from the place. To prevent the repeated destruction of the approaches, and the continual loss of the working parties engaged in their construction, a guard of sufficient strength must always be stationed within a distance from these works not exceeding the distance of these works from the covered-way of the place: so that a sortie issuing from the place for the purpose of destroying the approaches may be met and repulsed by the guard of the trenches before they can have time to carry their object into effect; and as the approaches themselves, from their limited dimensions, afford no accommodation for a guard of the trenches, a parallel must always be established at least as near to the head of the approacher as the heads of the approaches to the covered-way of the place.

It may then be considered a general principle of the attack that a new parallel or place of arms becomes necessary when the approaches have advanced half way between the last formed parallel and the covered-way of the fortress.

86. So soon therefore as the approaches have advanced half the distance between the first parallel and covered-way of the fortress, a second parallel must be established to accommodate a guard of the trenches, or the working parties at the heads of the approaches will be liable to be swept off by parties of cavalry issuing from the covered-way, before aid can reach them from the first parallel. The approaches are then pushed forward, parallels being made according to the principles just laid down, wherever required, until they reach nearly the crest of the covered-way. Here a trench of greater magnitude is formed, and in it batteries of heavy guns are constructed to silence the remaining artillery of the defence, and to breach in certain selected spots the escarp revetment wall, thus destroying the formidable obstacle to assault presented by the high perpendicular sides of the ditches of the fortress.

87. While the batteries XXII, XXIII, XXIV, XXV and XXVI (Fig. 57) are occupied in breaching the wall, the besiegers are busily employed in making a subterranean gallery from their lodgment on the glacis to the bottom of the ditch if dry, or to a little above the surface of the water in it if wet. In the former case the same kind of sap or approach is carried across the bottom of the ditch to the foot of the breach; in the latter case, a bridge or a solid causeway is made across the ditch by floating casks, fascines, gabions, sand bags, timber, or other materials, over the top of which a covered passage can be made. The besiegers' troops being thus enabled to march in perfect security to the opening or breach in the walls of the town, assault it in strong columns, and being much more numerous than the garrison defending the breach, soon overcome them, and the more easily, as they are assisted by a fire of artillery and musketry directed on the garrison from portions of the road only a few yards from the breach, and which fire can at that distance be maintained on the defenders of the breach till the very instant of personal contention, without injury to the assailants. The first breach being carried, should the garrison have any interior works, the covered road is by similar rules of art, pushed forward through the opening, and advanced batteries are erected in the work to overpower the remaining guns of

the place, which effected, the road is again pushed forward, and the troops march in security to the assault of breaches made in a similar manner in those interior works, and invariably carry them with little loss. When the besiegers are not pressed for time the loss of the few men attendant on the assault of the breaches under these favourable circumstances may be avoided, as at the expense of a little delay, the covered road, or sap, can be equally well pushed up and through the breach, without giving the assault, as after the breach has been carried; and thus by art and persevering labour, the strongest and most multiplied defences frequently fall without any exertion of open force.

88. It is then evident that the grand object in a siege is to carry forward the covered road to the walls of the place, and that all other operations are secondary to, and in furtherance of, such an advance; and consequently that the efficiency of armies at sieges depends upon their ability rapidly to complete the road, and at a small expense of life. The formation of the approaches or covered road is attended with difficulties varying in degree with its distance from the place. At the commencement, when beyond the range of small arms, the work can readily be performed by the ordinary soldiers of the army. When within fair range of musketry, 500 or 600 yards, it requires special precautions, but the work may still be performed by soldiers who have had a little previous training. But when it approaches close to the place—when every bullet takes effect —when to be seen is to be killed—when mine after mine blows up the head of the road, and with it every man and officer on the spot—when the space becomes so restricted that little or no front of defence can be obtained,—then the work becomes truly hazardous, and can only be performed by selected brave men, who have acquired a difficult and most dangerous art called Sapping, from which they are called Sappers. The last portions of the sap or covered road above ground are accompanied by the miner beneath, whose duty it is to listen for and discover the enemy's miner at work underground, and prevent his blowing up the head of the road; either by sinking down and meeting him, when a subterranean conflict ensues, or by running a gallery close to that of his opponent, and forcing him to quit his work by explosions of gunpowder and the combustion of suffocating compositions. Sappers of themselves, without the aid of skilful miners, would be unable to execute that part of the covered road forming the

descent into the ditch; and in various other portions of the road the assistance of the miner is indispensable to the sapper: indeed, without their joint labours and steady co-operation, no besiegers' approaches ever reached the walls of a fortress. A siege scientifically prosecuted is certain in its progress and results. More or less skill or exertion in the contending parties will prolong or shorten in some degree its duration; but the sapper and miner, skilfully directed and adequately supported, will surely surmount every obstacle. On the contrary, the sieges of armies destitute of these auxiliaries, are hazardous in the extreme. Their only chance of success is in scrutinizing the exterior of the fortress, to discover some spot from whence, in consequence of the irregularity of the ground, or faults of construction, the main escarp wall can be seen at a distance sufficiently great for ordinary soldiers to approach with the covered road, and there establish batteries to form an opening through the wall of the place. This effected, the soldiers must march to the assault, losing the shelter of the covered road at the moment when the fire of the place becomes most powerful and destructive; whereas the fire of the besiegers' distant batteries being necessarily suspended, to avoid killing their own storming party, the garrison can with impunity mount on their parapets, and use every kind of weapon and missile in their defence.

Should the columns, under these disadvantages, arrive in good order at the brink of the ditch, they must descend into it, down a wall from 14 to 16 feet in depth, which cannot fail to break their order and throw them into confusion. No fresh formation can be attempted in a spot where death is incessantly showering down on the assailants, and they rush to the breach more like a rabble than a solid column.

Details of Siege Operations against a Fortress on Vauban's first system (see Fig. 57), commencing from the formation of the first parallel.

89. As soon as it becomes dusk, the commanding engineer having previously well reconnoitred the ground, attended by others of the same corps and a few non-commissioned officers, should pace out the line of the first parallel, and the zig-zags of approaches to it. The officers should then divide the extent of the work between them, beginning at one end of the parallel; each taking a certain number

of yards according to the number of men in his division, should place a picket at the extremities of his portion of the work, and attaching to these pickets a white line or tape from one end to the other, he should make a man lie down by them, that they may be found with ease in the dark.

The sub-officers of brigades, after having well considered the spot, should return to the park, where the men for the working party would be assembled in readiness, and each should take charge of his division. The whole should then be marched to the place of breaking ground, where, whenever practicable, they should file along the whole length of the parallel, the officer with the leading section marching on till he arrives at the picket placed at the other extremity; each officer halting his division on arriving at his extreme picket.

Every man on marching out of the park should carry a shovel, a pickaxe, and a fascine 4 feet in length, which on the division halting he should place down parallel to, and 2 feet in front of, the white line.

The workmen being placed 4 or 6 feet apart, should, at the given signal, open the ground up to the line,—throwing the earth beyond the fascine, by which a space of 2 feet would be left for the banquette, —and dig a trench 3 feet deep, and 3 feet 6 inches wide at the bottom, or something more than a cubic yard and a half before being relieved. Under a heavy fire, men would effect this in three hours. It is recommended that the working party should have their fire-arms; for when without them, they are apt to disperse on the slightest alarm, and it is very difficult to collect them again. Their arms are an impediment, but the inconvenience is much overbalanced by the confidence it inspires, and the security it affords. This working party should always be preceded by a covering party, which generally would lie down a little before the tape to which they would be conducted by an engineer officer, well acquainted with its position.

Small platoons of men should be placed in their front with advanced sentinels, who should not on any account fire, and the platoons should only do so when assured of a sortie advancing in force.

Besides the working party to execute the first parallel on the night of breaking ground, a detail should be told off to connect the parallel with the entrepôts in the rear, by means of zig-zag trenches of communication. Good epaulements should also be prepared behind the

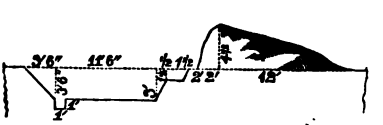
extremities of the first parallel, for the protection of cavalry, who may be required to act against sorties.

The moment that the parallel affords cover as well as room for the workmen to continue their excavation, the main body of the covering party should retire into it, leaving their pickets or sentinels in advance, but all are to be under cover by day-light next morning.

This parallel is widened and completed during the day after breaking ground, so as to afford a good covered post. It is intended as a place of arms, being furnished with a guard to protect the further approaches against the efforts of the garrison to retard or destroy them. Some engineers think it better not to place the guard in the parallel on the first day after breaking ground, as there is not sufficient room or cover for them and the working party without cramping the latter. They say, there is so little chance of an enemy's sortie at that distance, that it would be better to place only a few steady men with the working party, keeping the main force of the guard under some near natural cover until the evening, in readiness to advance, if required. They think, moreover, that a part of the guard by day might assist the working party with advantage.

The first parallel may be about 10 feet wide, clear of the banquette; but, against a weak garrison, this may be more than is necessary: 7 feet will, in many cases, be found wide enough, portions being here and there made sufficiently wide for two carriages to pass, when it is necessary for them to traverse the trenches. The parapet of this parallel serves as a screen, to hide what is going on behind it. It is not made shot-proof for a foot or two below its crest; nor is this of any great importance, as the enemy cannot afford to expend his ammunition unless, as before observed, he suspects some particular part of it to contain a body of men.

FIG. 59.



The extent of the first parallel depends on the nature of the works attacked, and its distance from the place, as well as the localities of the ground on which it is made. In Fig. 57, where the ground around is supposed to be a plain, the first parallel is of great extent,

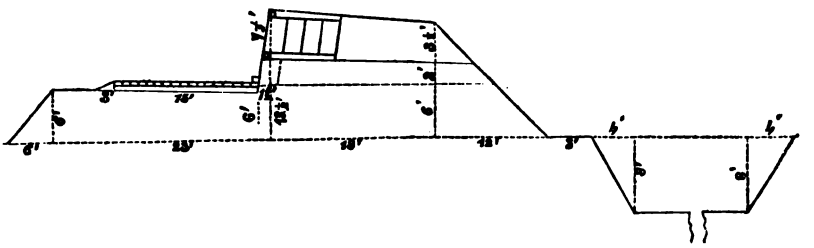
viz., about 3,100 yards: this arises from the necessity of enfilading the left face of ravelin F, and the right face of ravelin E, the guns of which command the ground to be worked over; and the parallel is extended so as to embrace the prolongations of these faces, where the batteries Nos. I. and IX. are constructed. But should the localities prevent the parallel being thus extended, and oblige the assailant to terminate at H and I the dotted battery, 40, would be made, in order to contend, by a direct fire, against the left face of ravelin F; and the battery, 41, against the right face of ravelin E. These batteries, 40 and 41, although armed with a greater quantity of artillery than Nos. I. and IX., would not be so efficient as the latter: as ricochet fire is far superior to direct fire for subduing an enemy's defences. It is, therefore, best, if possible, to extend the parallel, in order to obtain a good position for the batteries for ricochet practice. —Should the fire of the faces of any of the works, the prolongations of which fall beyond the sphere of the first parallel, become troublesome, batteries for subduing these defensive works by a direct fire, must be established: for instance, if the fire from the right face of bastion D disturbed the offensive proceedings, battery *z* should be erected to act against it, by a direct fire of heavy iron guns, and a vertical fire from mortars.

90. On the morning after breaking ground, the engineers should determine the positions in, or in front of, the first parallel, for the construction of the batteries to subdue the fire of the place. The situations for the ricochet and enfilade batteries are fixed at the spots, where the prolongations of the various works (which command the ground to be passed over) fall into the first parallel; and those for direct fire, are placed opposite to the faces of the works to be counter-battered. It is of the utmost consequence to complete the batteries on the first parallel as soon as possible, that the fire of the defences may be reduced and ultimately subdued, by the combined efforts of the enfilade, ricochet, direct, and vertical fires of the besiegers' batteries; for it is impossible to push on the trenches of attack, until the artillery fire of the place is nearly, if not altogether silenced.

These batteries may be cavalier batteries; elevated batteries; half-sunken batteries; sunken batteries. The first, or cavalier battery, has the platform for the gun-carriage above the level of the ground—that is, on a rampart. This construction is rare, as it involves great labour, requiring a large excavation in front, and many workmen to execute it.

FIG. 60.

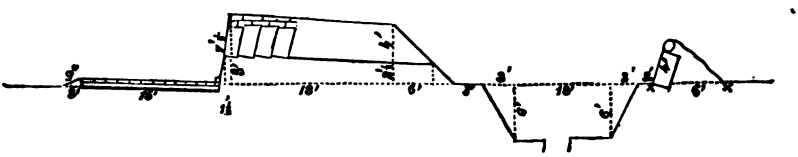
Cavalier Battery.



The second, or elevated battery, has a complete parapet, with the ditch in front, the platform for the gun-carrirge being laid on the level of the ground; it is in most general use, and in most cases, it is the easiest of construction.

FIG. 61.

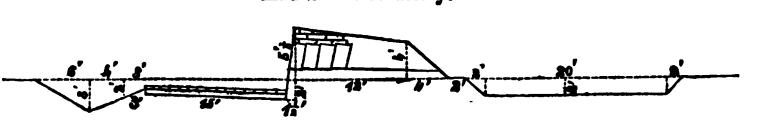
Elevated Battery.



The third, or half-sunken battery, has both an interior and exterior excavation of about two feet, to furnish earth for the parapet: that is, a trench in rear, and a ditch in front of the parapet. This kind of battery is suitable to rocky ground where there is only a thin layer of earth. Half-sunken batteries are the most expeditiously constructed of any, on account of their allowing double working parties to excavate and build the parapet; one set of men working in front, and another in rear of the parapet. In cases where securing cover expeditiously is of great importance, or where a shallow soil favours it, this double application of working parties has been found very useful, as it about halves the time usually employed in raising cover for troops, either in siege operations, or in securing a post exposed to a severe and destructive fire from an adjacent enemy.

FIG. 62.

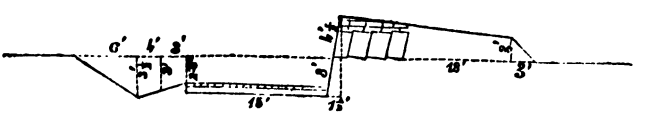
Half-Sunken Battery.



The fourth, or sunken battery, has its level about three feet below the ground line, so that the gun can range just above it. This construction is frequently used in turning the portion of a parallel into a battery, by increasing the width of the interior excavation of the trench so as to make room for the platforms of the guns. Great care must be taken that no rise in the ground before the battery obscures the view from the soles of the embrasures; for this purpose, the officer laying out the battery should lie down and look along the ground, in order to be sure that his guns can range freely from their embrasures, before he fixes his details for construction. When guns are fired with an elevation—when the soil is sandy or gravelly—when the weather is dry—or the ground elevated, this construction is approved. The depth of the excavation for the interior must depend on the height of the carriages upon which the guns are mounted; it should be deeper in rear than in front, that it may be drained.

FIG. 63.

Sunken Battery.



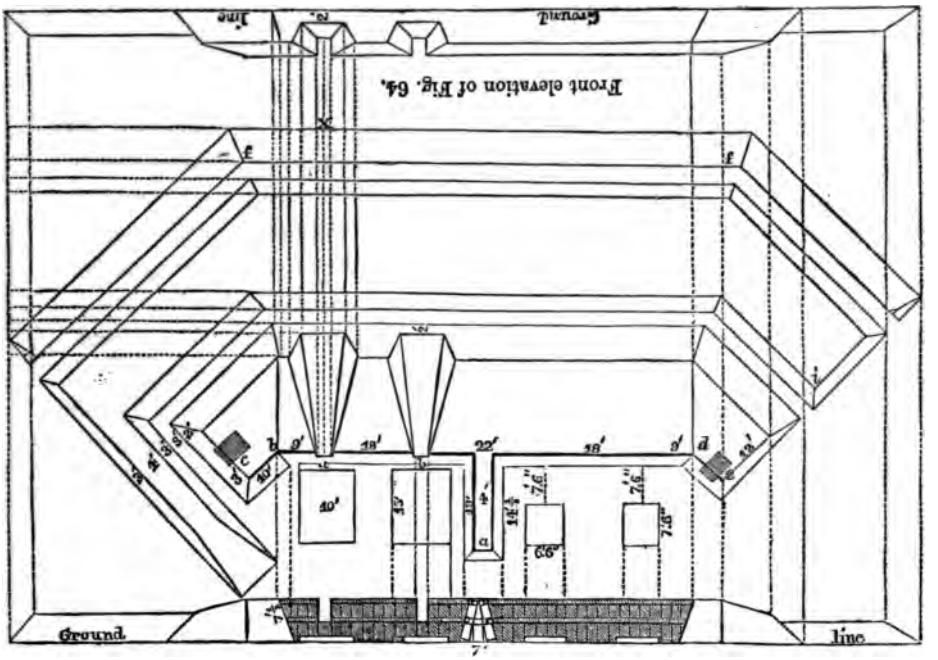
The interior slopes of these batteries, and the cheeks of the embrasures, must be supported by field revetments of gabions, fascines, sandbags, casks, or sods.

In batteries exposed to a heavy fire, especially of shells, it is necessary to provide as much cover as possible for the men serving in them; for this purpose, traverses are usually placed between every two guns; and as these masses serve to protect the men from the splinters of the bursting shells, they are generally called splinter proof traverses.

91. The following figures, 64 and 65, should be minutely examined, in order to gain the requisite information on the construction and dimensions of batteries in general. Fig. 64 is a plan of an elevated battery for two guns and two mortars, with a splinter-proof traverse *a* between them. Above it is a front elevation,* and beneath

* To comprehend which, the figures must be reversed, or turned upside down; when it will appear as seen from the outside of the battery.

FIG. 64.



Rear elevation of Fig. 64.

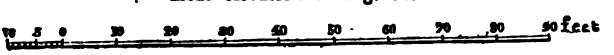
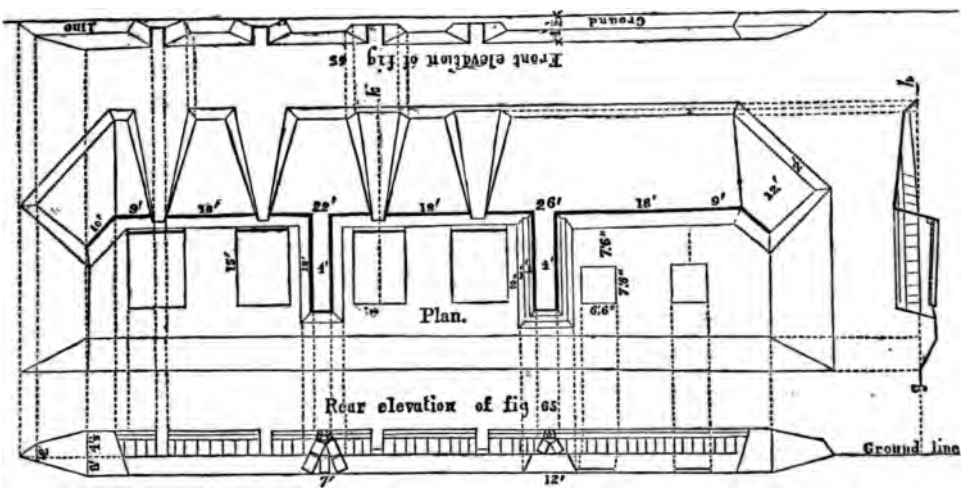


FIG. 65.

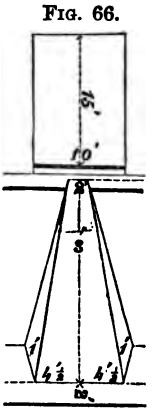


it is a rear elevation of the same battery. It has two short shoulders or epaulements *b c, d e*. On the edge of the reverse slope of the

ditch, there is a line of gabions which would range along the line *f f*, of fig. 64; these are not shown in the plan, but they may be seen in the section, fig. 61. In such constructions, which are usually made within the range of grape and canister-shot from an enemy, the workmen would, in all probability, place this line of gabions first, excavate a trench in rear of them, fill them with earth, and make a bank or parapet, in order to obtain cover; afterwards, this trench would be enlarged to a ditch, and the earth obtained thrown inwards to form the parapets of the battery. The parapets of the shoulders need not be so thick, as they are usually exposed only to an oblique fire. When the battery is completed, and the guns ready to open, this exterior line of gabions may be removed entirely, or in part, in order that the guns may have free scope for their fire. On the left flank of fig. 64, it may be observed, that there is a slope or ramp, leading from the interior of the battery down to the bottom of the ditch, in order to form a communication with it, which would not be exposed to an enemy's view.

99. The embrasures are here shown as 9 feet wide at the mouth of the sole, and 11 feet at the foot of the superior slope; but should the gun be intended for enfilading fire with diminished charges, the explosive effects of the charges will be less, and the mouth of the embrasures may be diminished with advantage as the parapet will become more solid and firm, and the men better protected. The engineer charged with the construction of the battery must exercise his own discretion and judgment in tracing the embrasures of the dimensions suited to the objects in view: but the general rule given by Sir Charles Pasley under ordinary circumstances is this. Let the sole of the embrasure (fig. 66) be 2 feet wide at the neck, and 5 feet down or from it, 3 feet wide. Lines drawn on each side from the former, through the latter points, will give the right width at the mouth whatever may be the thickness of the parapet.

Fig. 66.



100. Figure 67 shows an embrasure provided with a musket-shot-proof shutter, or mantlet, used when an enemy is within the range of musketry, in order to protect the gunners as much as possible from the shower of musket-bullets constantly fired into the embrasures in order to silence the fire of the guns. Fig. 68 is a section of this mantlet.

Fig. 67.

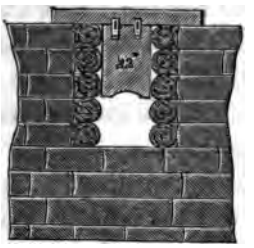
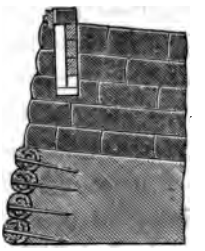


Fig. 68.



101. Howitzer batteries have usually the necks of their embrasures a little wider than long-gun batteries. All short guns in batteries, such as the old howitzers and carronades, have the disadvantage of requiring wide necks for their embrasures, and thereby exposing the gunners. The flash and expansion of the elastic fluid, on the explosion of the charge, taking place at the neck, soon ruins the embrasures. Howitzers and guns for ricochet being fired with a little elevation, may have the soles of their embrasures countersloping, that is, sloping inwards; which adds something to the general stability of the mass. Indeed, when howitzers are fired at considerable elevations, that is, 10° or 12°, the parapets of their batteries may be countersloping and without embrasures, unless a fire of musketry is likely to be required from the battery, in which case the superior slope must have the usual depression to the front, but the parapet may be solid.

102. Mortar batteries have no embrasures (fig. 65): their superior slope may be flat at top, or even have a counterslope, if no musketry fire be expected from them. Mortars are usually placed at 15 or 18 feet apart, and when fired at 45° of elevation, they are removed to a distance of about 12 feet from the epaulement: as the angle of elevation is decreased, the pieces are proportionally removed to a greater distance from the parapet.

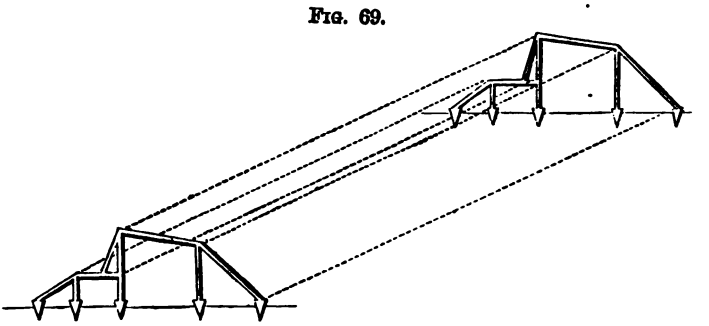
103. Rules for tracing an elevated gun battery on the ground similar to fig. 64, but for two guns, two howitzers, and two mortars, and without the gabionade. *See* figure 70.

First mark the interior base line of the parapet perpendicular to the prolongation of the crest of the work to be fired at, if it be intended for an enfilading battery, but parallel to the face, if it be to counter-batter or to breach the work. The proper length for this base line may be found by multiplying the usual distance between two embrasures, viz., 18 feet by the number of guns, howitzers, and

mortars, intended to form the battery, adding to the quotient 6 feet for each splinter-proof traverse that may be required; next trace the interior base lines of the epaulements which should form an angle not less, but rather greater than a right angle, with the base line of the parapet, the length being sufficient to defend the gunners from the enfilading fire of the enemy, say about 6 yards.

104. Profiles (fig. 69) formed of laths nailed together in the shape of the intended parapet may now be set up; the interior slope with a base of 1½ feet, and a height of 7½ feet; the superior slope a base of 18 feet, with a dip of 18 inches; the exterior slope with a base equal to its height, 6 feet, total 25½ feet. On the supposition that

Fig. 69.



the enemy will not be able to bring a direct fire against the epaulements, a base of 12 feet may be sufficient for their superior slope, with 6½ feet for the exterior slope, making, together with the interior slope, a total base of 20 feet for the epaulements. But as the interior slope of the epaulement would be rarely revetted, a base of 4 or even 6 feet would be required should the earth be loose, which must be taken into the calculation when fixing the length of the interior base line of the battery.

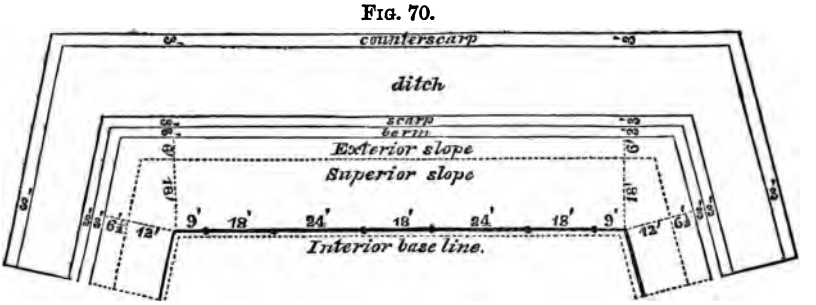
105. After setting up the profiles, the next thing to be traced on the ground is the interior and exterior berm line, and another 3 feet beyond it to define the foot of the scarp of the ditch, which on the above supposition will be 31½ feet from the interior base line of the parapet. In like manner with reference to the epaulements, at the distance of 20 and 23 feet from the revetted interior base line, picket off on the ground, the berm, and 3 feet beyond, another line for the foot of the scarp of the ditch of the epaulement.

106. The calculation of the deblai having been made to ascertain the breadth of the ditch, trace the line of the foot of the counterscarp,

and mark it on the ground between this and the line denoting the foot of the scarp; the excavation in the first instance is to be made, the sides of the ditch being sloped off at a later period; but should there be a gabionade as in fig. 61, the line denoting its intended position should be picketed off before the diggers commence, as the formation of this parapet by flying-sap for their protection, while throwing up the parapet of the battery will first engage their attention.

107. While this is being done, let pickets be driven in on the interior base line of the parapet to show the position of the middle of each of the embrasures, which position is to be found by subdividing the whole length of the face or 120 feet into two half merlons of 9 feet each (one at each extremity of the base line), three common merlons of 18 feet each, and two large merlons of 24 feet each, the latter having an extra length of 6 feet, on account of the splinter-proof traverses which are to be placed behind them. The tracing at this stage is represented by the following diagram. The dotted lines at right angles with the crest show the direction in which the profiles should be set up, the base of that for the parapet being equal to 25½ feet, while that for the epaulement is equal to 20 feet. The dotted lines parallel to the crest indicate the foot of the interior and superior slopes.

Fig. 70.



108. In revetting the interior slope of this elevated battery with sap gabions, the ground should be levelled, if uneven, and a groove formed on the base line, in which to place fascines, along its whole length. Let these be about half buried in the earth, and on them place a row of gabions, so that they interiorly rest upon the foundation of the fascines, by which they will have the proper inclination outwards, that is, forming a slope of one-fourth of their height. These gabions should be filled with earth excavated from beyond the line, which denotes the foot of the scarp of the ditch, and moderately rammed, so as not to strain them, from whence also all the earth should be taken to form the lower part of the parapet called the solid, the

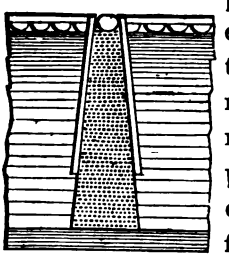
inner part of which is to be level with the upper part of the gabions; but about 1 foot lower in front.

109. The solid being completed to its proper slope opposite each of the embrasure pickets, the splay of the cheeks of these should be marked out by the rule laid down in fig. 66, and defined by two fascines (one on each side), their inner ends at the neck being 2 feet apart, and at 5 feet from the interior slope, that distance increasing to 3 feet; at the same time a second course of fascines is added to the interior revetment of the parapet, which is laid over the gabions, extending in each merlon from one embrasure fascine to the other, thus filling the interval between the two. The annexed figure 71, is a section through the parapet of an elevated battery, at this stage of progress supposed to be taken through one of the proposed merlons.

FIG. 71.

Fig. 72 represents a plan of one of the embrasures at the same period, showing the solid just completed, and the embrasure marked with a couple of fascines, and the second course of fascines in the rear of the parapet placed. The embrasure fascines are carried back as far as the interior slope of the parapet, so that their ends are seen in a rear elevation of the parapet of the battery. *See* fig. 74.

FIG. 72.



After the whole of the fascines which mark the form of the embrasures and merlons are thus laid, and backed with earth as much as may be necessary, a second course of gabions is placed over them. Those for the parapet or back of the merlon are carefully placed, by the same rule as the first course of gabions below, so that when finished the whole interior revetment of the parapet shall have the same uniform slope of one-fourth of its height throughout. The gabions in the cheeks of the embrasures on the contrary are placed with a variable slope, as will afterwards be explained. Although the sap gabions measure only 2 feet 9 inches high in the web, they are found to average 3 feet each in a parapet, owing to the projecting ends of the pickets. Hence the second course of gabions will very nearly complete the parapet to the height of 7 feet 6 inches, the deficiency may be made up of sods or rammed earth. The following cut,

Fig. 73.

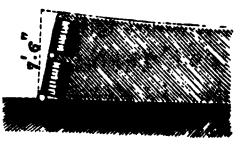


Fig. 73 represents a section of the interior revetment of the parapet, thus finished as taken through the middle of the merlon. Under the peculiar circumstances of a battery constructed against a very commanding work, it might be necessary to raise the parapet higher than the usual standard of 7½ feet. In this case whatever height may be required over and above that which is afforded by the second course of gabions must be made up with fascines. Thus, for example, if the parapet were required to be 9 feet high, it would be proper to add two courses of fascines at the top, but if any part of the height necessary should involve a fractional part of a fascine's height, this may be revetted with sods.

110. Fig. 74 represents the rear elevation of a two-gun portion of an elevated battery revetted with gabions. In this figure the two gabions at the necks of the embrasures are made to assume a small degree of slope which may usually be done, because the gabions one with another occupy rather less than the regular average space of 2 feet each, when placed very close together, so that those of the upper tier will generally admit of being closed at top, and eased at bottom to favour this arrangement. If not, the neck of the embrasure may be made of equal width throughout without attempting the kind of slope alluded to; but the gabions which form the cheeks of the embrasures should have a slope gradually increasing from the neck towards the front, until the fifth gabion (more than five will seldom be used) has a slope of at least one-third of its height.

Fig. 74.

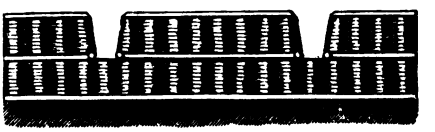


Fig. 75 is the plan of a portion of parapet and embrasure, showing the arrangement of gabions above adverted to.

Fig. 75.

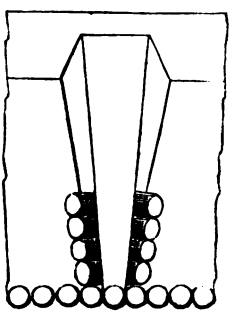


Fig. 76.

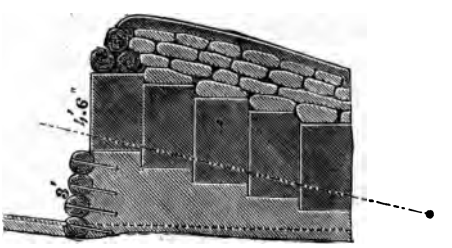
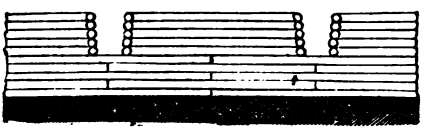


Fig. 76 shows in elevation the arrangement of the gabions and of the sand-bags above them, as well as the genouillere or solid part of the embrasure, below the sole of it, in a construction that frequently arises in sieges, especially in the offensive crowning batteries on the crest of the glacis, where the depression of the sole of the embrasure is considerable, to allow of the guns being pointed to spots of the wall some distance below them.

111. Fig. 77 represents a portion of the parapet of a gun battery revetted with fascines. The ground should be prepared in the same manner as before alluded to for gabions. It should if necessary be levelled, and a groove made for the first row, which should be about half buried to serve as a foundation, and to prevent the interior slope from slipping at its foot. The fascines should be built up in successive courses and bonded with earth, to which they should be picketed, and occasionally to one another in the proportion of about 6 pickets to an 18-feet fascine; each succeeding course should break the joints of the one below it, the earth being raised as high as the fascines before another row is placed. The pickets in the lower tier should be driven perpendicularly through the fascine into the ground, while those through the others should be driven obliquely downwards into the parapet, forming less than a right angle with the interior slope, some being driven as before observed into the fascines below to bind the mass together. Fig. 15 is a section of a parapet so revetted with fascines.

FIG. 77.



112. In revetting the embrasures with fascines, the same attention must be given to their sloping cheeks, as was directed in the case of gabions. The ends of the fascines at the neck of the embrasure, should coincide with the interior slope, and rest one upon the other so that the sides of the embrasure are nearly perpendicular at the neck. It is recommended to revet the cheeks with 9-feet instead of 18 feet fascines, and without breaking the joints, by which the part most likely to be destroyed by the concussion of the air in firing, can be repaired with greater facility. During the progress of the interior revetment and the formation of the embrasures, men who have been told off for this purpose are supposed to have been forming the traverses and the epaulements,

113. From 9 to 12 men per gun would be desirable to construct

an elevated gabion gun battery, according to the character of the soil. Berms are very useful in giving stability to parapets in loose soils, and also for throwing the earth upon when the ditch is deep or wide, from whence it is again thrown within the profile of the parapet; nevertheless, they are frequently omitted in the tracing.

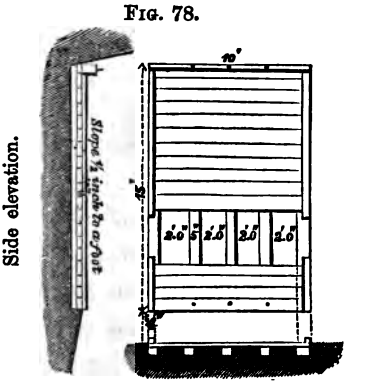
114. Platforms for guns. To enable a gun to be worked with ease, expedition, and accuracy, it must be placed on a platform. In permanent fortification, platforms are sometimes made of stone, but in field works they are always of timber; they are composed of beams or sleepers covered over with a flooring or deck. For guns, the platforms are laid with a slight rise of about half an inch to a foot in the rear; therefore, as the platforms are usually 15 feet long, there is a rise of 7½ inches from front to rear. A gun or howitzer platform (Fig. 78) consists of—

5 Sleepers, each 15 feet long; 5″ square.
20 Planks, each 10½ feet long; 9″ broad and 2″ thick.
2 Ribbands, each 15 feet long and 4″ square.
10 Rack-sticks and lashings, or iron bolts.

The weight of this platform averages—according to the nature of the wood—about 13¼ cwt.

The sleepers must be well embedded in cuts or trenches, and firmly fixed or pinned into the earth, then covered with the planks, and finally completed by the two ribbands, and five rack-lashings on each side. This platform is rectangular in shape, and each one of the sleepers and each one of the planks is exactly like every other of the same class, so that the position occupied by any particular sleeper or by any particular plank is quite immaterial, and the platform can be put together, at night or under fire, the circumstances under which batteries are generally constructed, without confusion and without delay; and as the batteries at a siege are usually made for a specific object, the guns are seldom required to traverse to any considerable extent to the right or to the left of the central line of fire, and the platform is therefore sufficiently spacious.

FIG. 78.



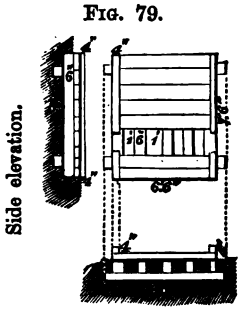
In permanent works, where it is important that the guns should be able to sweep a considerable angle, the platforms are made to increase in width towards the rear. In such platforms each individual plank, and each individual sleeper has its proper position, and will fit no other, and they require, therefore, much care and considerable time to construct. In addition to this, the liability of the parts to disarrangement during transport increases the objections to such an extent as entirely to preclude their adoption in field operations.

There are three modes of fastening the flooring or deck to the sleepers—by screws, spikes, and rack-lashings. When the latter are used they must be arranged in their proper places, when the two outer sleepers are first laid in their grooves or trenches in the earth. This platform may be laid down in an hour by expert men, and may be dismantled in a few minutes.

115. Platforms for mortars (Fig. 79) should be horizontally laid. Each consists of—

7 Sleepers; 5 of which are laid longitudinally, and 2 transversely, underneath the 5; all well embedded in trenches in the ground; each sleeper 7 feet 6 inches long and 6 inches square; 8 planks, 6 feet 6 inches long, 11¼ inches broad, and 4 inches thick.

FIG. 79.



2 Ribbands, 7 feet 6 inches long and 4 inches square.

10 Rack-sticks and lashings.

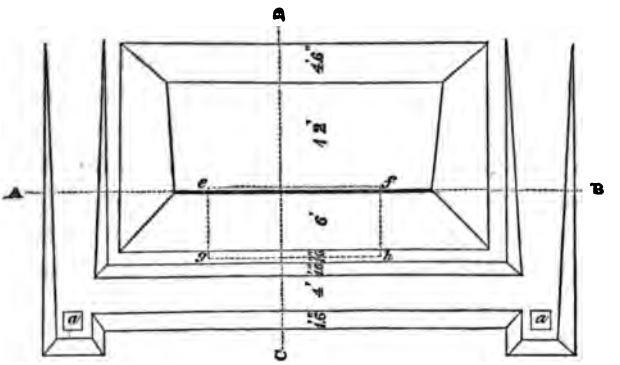
The weight depends upon the nature of the wood, averaging about 9 cwt.

116. As the recoil of a mortar fired at 45° of elevation is more direct on the platform, it is necessary to make a mortar platform stronger than a gun platform; hence 7 sleepers are used instead of 5, and the scantling of the sleepers and flooring is greater in the mortar than in the gun platform.

All the batteries of the Attack require magazines capable of holding sufficient ammunition for at least daily consumption. These magazines must be proof against splinters of shells, and should be placed in positions as secure as circumstances will permit from the enemy's fire. In Figs. 80 to 84 are shown a plan and sections of two magazines, according to General Sir C. Pasley's construction.

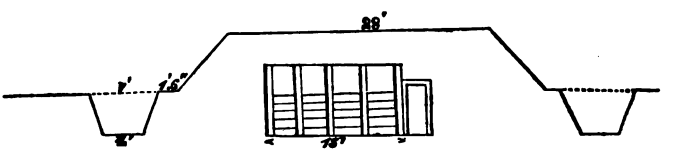
The magazine shown in Fig. 80 is intended to be made in rear of the centre of a battery ;—

FIG. 80.



After tracing it distinctly on the ground and setting up the profiles, the space *e f h g*, is excavated for the frame-work of the magazine, sections of which are seen in Figs. 81 and 82 ; ramps lead from the

FIG. 81.
Section on A. B.



battery into the ditch or trench in rear of and parallel to *g h*, having little cesspools *a a* ; the bottom of the magazine may be about 8 feet below the ground line ; the side *e f* is lined with planks or fascines, as seen in Figs. 81 and 82. A smaller frame is seen in Fig. 81, as the doorway, leading into the magazine from the trench. The sloping side-beams, from *g h* to *e f*, are covered with stout fascines ; one row or tier is seen in Fig. 82 ; but two may be used, as from their elasticity they form a good covering for a magazine, effectually resisting the splinters of shells. This magazine is capable of holding 55 barrels of gunpowder. Fig. 83 is a transverse section of the other magazine, which, from its rectangular shape, holds more powder than the triangular shape ; but the latter is considered the best for resisting the fall of small shells or the splinters of larger. The section shows the

FIG. 82.
Section on C. D.

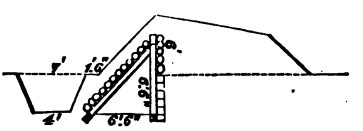
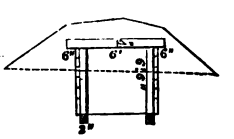


FIG. 83.



shape of the covering mass of earth over the rectangular magazine, the trench and ramps being the same in both.

117. Fig. 84 is a section of two strong splinter-proof timbers,* say 8 to 9 feet long, and 9″ or 12″ square, resting on sleepers, and giving an interior space of about the dimensions seen in the figure, covered with one or two tiers of fascines, and over them 3 or 4 feet of dung or stiff earth; this simple construction would answer in many cases. By some persons it is considered better to have two small magazines in a battery, made of very stout mining cases, and constructed in the epaulements, as at *c* and *e*, Fig. 64.

FIG. 84.

Sir John Jones, in his work on "Sieges," makes the following remarks on this subject: "Splinter-proof timbers for magazines were cut 12 feet in length, and from 8 to 10 inches in breadth and thickness, and were placed against an epaulement, or parapet, at an angle, making the base equal to half the height. They were then covered with a tarpaulin, extending well over the top of the epaulement, upon which were laid one or two rows of filled sand-bags, so as to prevent the possibility of the tarpaulin being cut by splinters of shells. A second tarpaulin was usually thrown over the exterior in rainy weather. On this construction, the magazines were found to be perfectly dry, and sufficiently spacious, and of the strength no doubt can remain, as the sand-bag covering was frequently knocked off by large shells, and in no instance were the splinter-proofs broken.

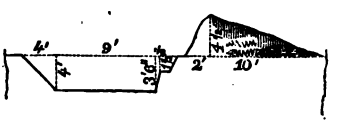
"The best situations for magazines are on the flanks of the batteries. Nothing can be worse than to place them in rear of the centre of a battery, as then every cartridge has to be carried along the most exposed and dangerous part of the battery, and the number of accidents and casualties which arise therefrom is very great indeed. The artillery always preferred having two magazines formed, rather than to have one exceeding 10 or 12 feet in length; when two were made, they were placed one on either flank, a situation which was found to answer extremely well. For the magazines of batteries constructed in advance of a parallel, a cut was made perpendicularly through the parapet, at the extremity of the communication from the

* This name is given, because the arrangement is merely intended to be proof against the splinters of bursting shells; a heavy shell falling upon the contrivances now referred to, would crush them in; but being very small objects, this evil rarely occurs.

parallel, at 10 or 12 yards before arriving at the battery. The level of the floor of the magazine was then kept as nearly on the level of the approach as would admit of its being drained; and the foot of the splinter-timber was sunk 12 or 14 inches under it. In this situation an accidental explosion of the magazine would not injure the battery."

117. The batteries in the first parallel having been completed, and having established a superiority of fire over the artillery of the fortress, the zig-zags of approach may be carried forward on the capitals of the bastions and ravelins.

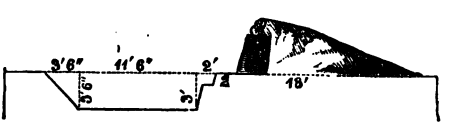
FIG. 85.



Zig-zag of Approach.

In these positions they do not interfere with the enfilading batteries, and are least exposed to the direct fire of the fortress. While distant from the place they will be made by flying-sap. When the approaches have passed over half the distance between the first parallel and the crest of the covered way, it becomes necessary to form a second parallel. The execution of this work will be carried out thus:—

FIG. 86.



Second Parallel.

118. At dusk, the engineers start from certain fixed points in the first parallel, walking towards some defined objects until they have passed over half the distance towards the place; they then connect their positions by white tapes picketed down, which mark the position of the second parallel. The working parties again assemble before dusk at the engineers' depôt, where their tools have been previously arranged in columns, behind which the divisions file. Each man takes

two gabions, a shovel, and a pick-axe. The working party, as before, is preceded by a covering party, having an advanced chain of sentries, the whole supported by battalions in the most advanced zig-zags or approaches. Each engineer conducts his men, and sees their gabions placed close together, at 2 feet in front of the white tape. The men then lie down till the engineers have ascertained that the whole are connected and ready, when at the appointed signal the excavation begins. The gabions should be filled, and musket-shot proof, in ten or twelve minutes, after which the earth excavated is thrown beyond the gabions, to form the parapet. Ample cover should be obtained by day-light next morning, as well as a respectable width of trench finished, as the portion to be executed by each man is only equal in length to the space occupied by two gabions. This process is called the flying-sap.

The second parallel and all other parallels nearer to the place from their greater proximity and smaller extent, are far more likely than the first parallel to become the objects of a serious artillery attack. To prevent their destruction and the consequent interruption of the communications within them, their parapets must be thick enough to withstand the artillery fire of the place, that is, they must have a base of 18 feet, at the least.

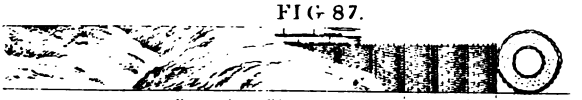
119. On the night of constructing the second parallel, some zig-zags of approach beyond it may be traced and executed by the flying-sap. But from the proximity of the place, few opportunities will afterwards occur for using this expeditious mode of carrying forward the approaches, unless the fire be very slack indeed.

It is customary to protect the extremities of the second parallel, by forming redoubts to contain a few pieces of light artillery, and a strong detachment to repel sorties. The rear faces of such redoubts, not being exposed to the fire of the place, need not be of so strong a profile as the front faces. Instead of a redoubt, one of the extremities of the second parallel may be continued in a defiladed curve to the rear, to join the first; thus affording the advantage of shutting in the ground between the parallels, and of giving an additional trench of communication.

If the defence be not very active, the extremities may be left en l'air, or open, terminated at the points marked 43 and 46 (Fig. 57). Should the ground be level, the second parallel will not interfere with the fire from the ricochet batteries in the first, for the guns being fired

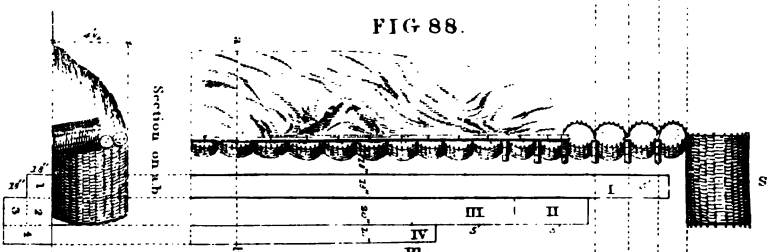
FIG 87.

SINGLE SAP



Exterior Elevation

FIG 88.



Plan

SCALE OF FEET FOR FIGS 87 88 & 89.

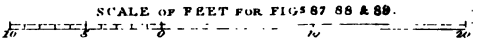
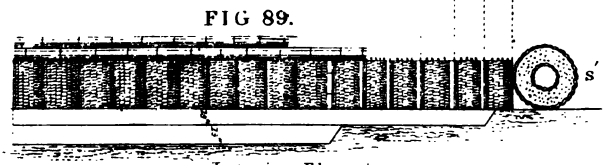
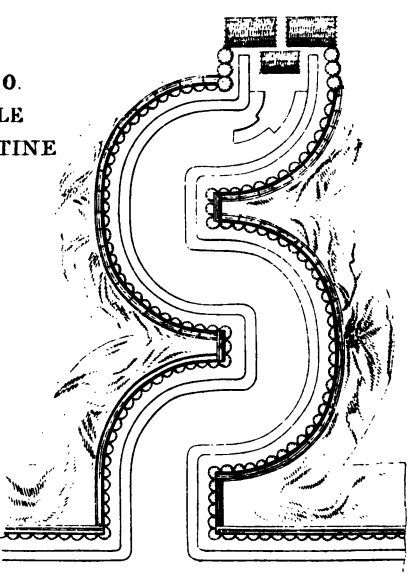


FIG 89.

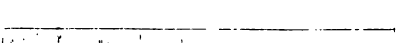


Interior Elevation

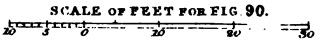
FIG. 90.
DOUBLE
SERPENTINE
SAP.



PARALLEL



SCALE OF FEET FOR FIG. 90.



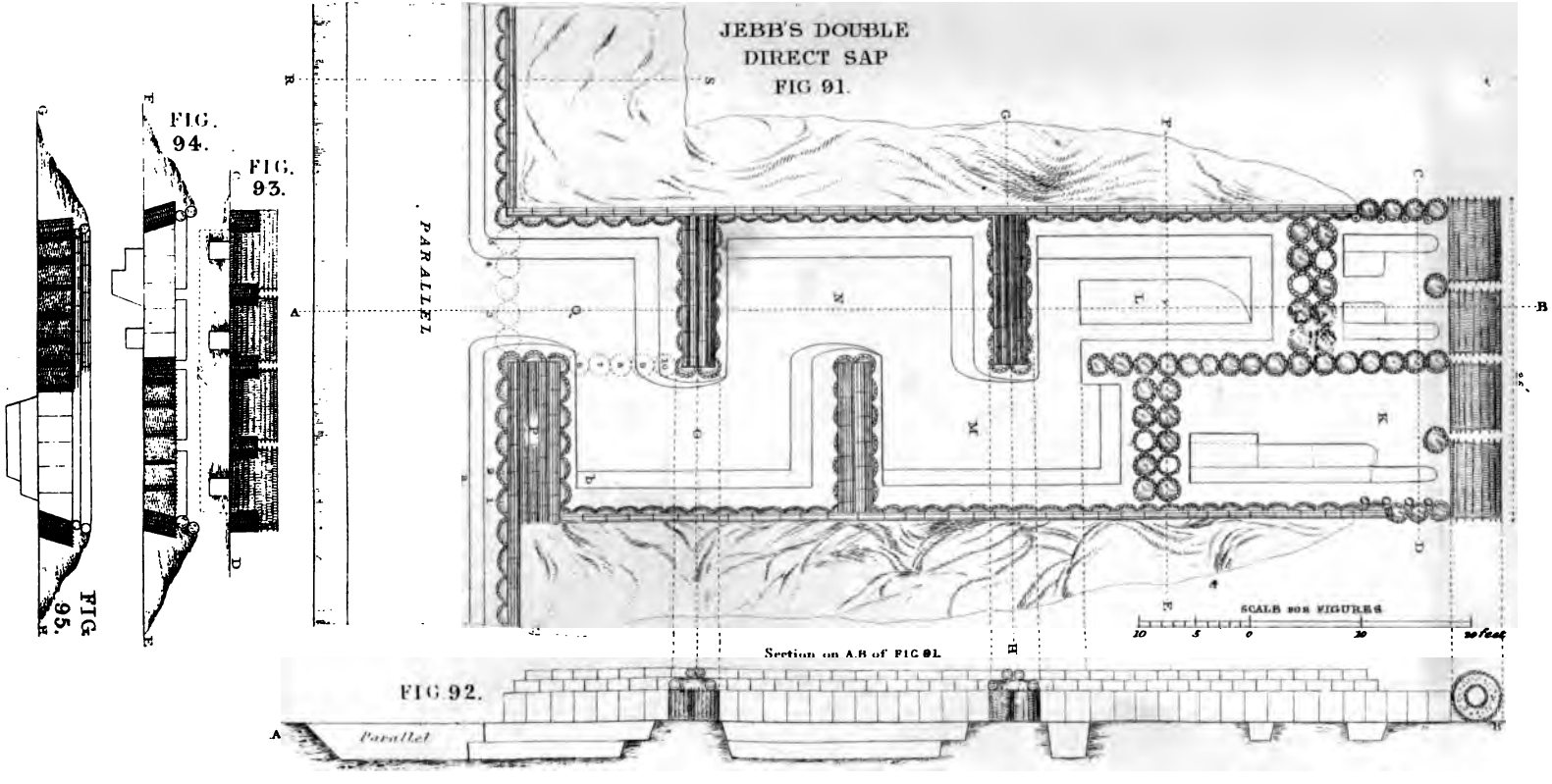
with an elevation, the second parallel will be nearly under the highest part of the curve, described by the flight of the shot. But should the localities of the ground cause it to mask the fire from these guns, fresh batteries in corresponding positions must be constructed in the second parallel. The dotted outlines marked 2, 4, 5, 5′, 6 and 8, indicate the positions of the new batteries to receive the guns from those in the first parallel. The mortars will seldom require removal as the ample curves described by their projectiles render them generally independent of inequalities of ground. The direct batteries must be brought forward, as the fire will be much more powerful, and the practice more certain, than when at the greater distance. The left flank of bastion A, and the right flank of bastion B, might each be enfiladed by an 8-inch howitzer from batteries 47 and 48 in the second parallel. Under all circumstances, the fire must be unremittingly kept up, in order to keep down the artillery of the place, for all the trenches beyond the second parallel are formed by the sap, which cannot be conducted against the fire of artillery; therefore the disarming of the one and the arming of the other batteries should be gradually performed, so as not very sensibly to diminish the fire.

120. The zig-zags of approach are now pushed on by sap; an operation performed by sappers, or engineer soldiers, who must be well instructed in their business: it is a slow operation, as the work cannot proceed more rapidly than one man can dig at a time. For this duty, the sappers are told off into squads or brigades of four men each, and they are numbered 1, 2, 3, 4: the man at the head of the squad is called the first sapper. The head of the trench which they dig, is covered by a sap-roller: and on the flank whence the fire comes the sappers are protected by a line of gabions filled with earth. Fig. 88 shows a plan and transverse section of a single sap, with the work of each sapper numbered; Fig. 87 is an exterior, and Fig. 89 an interior, elevation of the same. The first sapper cuts the trench marked I in the plan and 1 in the section, making it 18 inches wide and 18 inches deep: No. 1 sapper also places each successive gabion: he works on his knees, taking care to leave a banquette of 18 inches between his trench and the row of gabions. He is very careful not to allow his body to pass the gabion last placed till he has filled it with earth, and placed a sap-fascine or a couple of sand-bags in the hollow, between the two advanced gabions, so as to have a musket-shot proof

cover behind which to continue his work. He also, assisted by No. 2, pushes on the sap-roller (S) by means of forks having long handles: the leading sapper thus occupies the most dangerous as well as the most laborious post, therefore each of the squad takes it in succession. No. 2, at the distance of 5 feet from No. 1, with whose trench he does not interfere, also works on his knees, and excavates the trench marked II. in the plan and 2 in the section: to equalize the work, his trench is 20 inches wide and 18 inches deep.—No. 3 follows No. 2, at the same distance in his rear, deepening the trench of the latter to 3 feet, marked III. in the plan and 3 in the section underneath.—No. 4 completes the trench by increasing its general breadth 10 inches. His work is marked IV. in the plan and 4 in the section. The earth excavated by the squads is first put into the gabions and afterwards thrown beyond them, so as to form the rough parapet seen in the plan and section. Working parties follow the sappers, and complete the trench to any dimensions that may be required.—In sapping, or in using gabions as a revetment, &c., they should always have a little slope outwards towards the parapet, of about one-eighth of their height; for, if placed quite upright, any swelling of the fresh earth of the parapet from rain, might throw them down inwards. By examining the plan, section, and elevations of this single sap, the pupil will become fully acquainted with all its details: the sap-faggots need only be used between the gabions where there is no earth beyond them.

The time occupied in constructing 10 feet of sap, in the manner just described, is about one hour; but if, during the night, the fire from the place slacken, portions of sap may be pushed on more rapidly by placing several gabions at a time, and filling them simultaneously: when this is done, it is called the flying-sap.

121. Approaches by sap being usually carried along the capitals of attacked works, in a zigzag direction: each successive zigzag being directed so as to be clear of enfilade from the place, their parapets run obliquely to the place; but when the saps draw near, these zigzags become so multiplied, and the angles between them so acute, that it saves time in many cases to carry on a direct double sap towards the place. Thus when 100 yards of zig-zag do not carry the approaches so much as 32 yards in advance, a direct double sap should be adopted. In constructing this sap two brigades of sappers are employed at a time, each being covered in front by a sap-roller.


JEBB'S DOUBLE
DIRECT SAP
FIG 91.
PARALLEL
SCALE FOR FIGURES
Section on A.B of FIG 91.
FIG 92.
Parallel
FIG. 93.
FIG. 94.
FIG. 95.

The gabions forming the parapets of the sap are usually 12 feet 6 inches asunder: the intervals between the sap-rollers being covered by a short sap roller. This double sap is therefore a mode of advancing against a musketry fire in the front and on the flanks. Should the sap be liable to be enfiladed or raked, it must be traversed, it is then called a double serpentine-sap; that is, instead of being carried on in a straight line, the squads of sappers work round solid dies of earth, which form the traverses (*see* Fig. 90), in a serpentine direction, whence it derives its name.

122. Another kind, to which the preference is given, is called Jebb's double direct sap. This is worked by three brigades of sappers, with four sap-rollers in front. Fig. 91 is a plan, and Fig. 92 is a longitudinal section of this sap taken through A B. Figs. 93, 94, and 95 are transverse sections taken through C D, E F, and G H respectively. The work of each brigade is the same as in the single sap: an inspection of these figures will show the progress of the sap and its details. The gabions, in the two traverses near the head of the sap, are unshaded to show that they are not filled with earth, and as they can be easily removed, will allow a sapper to creep in to keep up a communication. As the three squads work steadily in advance, others following them lay out and complete the traverses, for which purpose part of the excavated work must be filled in again: this is a loss of time, but it is more than compensated by the security and general expedition of the sap. In Fig. 90, the sappers have to wheel the great unwieldy sap-rollers in working round a solid die of earth in order to form a traverse, which is a dangerous process, and so exposes the men that expert riflemen are sure to find fatal openings: but in Jebb's direct sap, the sap-rollers move steadily on in one line, and thus keep the men well covered at work.—In order to commence such a sap from a parallel, the sap-rollers are carefully passed over the top of the parapet of the parallel by means of planks or scantlings and ropes. Suppose the four sap-rollers of this sap to be thus passed over the parapet of the parallel, the three brigades of sappers then commence their respective duties (see Fig. 91). The right brigade removes gabions 1 and 2, and No. 1 sapper proceeds with his excavation; the others of his brigade complete the traverse P, assisted by the centre brigade (who have removed gabion 3), while No. 1 sapper of this brigade goes on with his excavation. The left brigade removes gabions 4 and 5, and proceeds with its regular work; first clearing away the parapet of the

parallel. Sappers No. 3 and 4 of the right brigade, afterwards fill in the excavation of No. 1 with fascines, from *a* to *b*, to make a good footing for the gabions 1 and 2, which they replace, and complete traverse P.—Gabions 6, 7, 8, 9, 10, should be placed so as to protect the workmen in the branches Q and O. This middle row of gabions placed by the centre brigade is shown towards the head of the sap, where the work of the three brigades equally in advance may be seen. Similar cover is used in each successive branch N M L K, &c. The traverses in the rear being completed, the middle line of gabions is removed.—In addition to the three brigades of sappers, a working party from the line is required to clear the branches Q O N, &c., and throw the earth over the gabions for the exterior parapet.—The distance of the parapets from each other, as shown in the plan, is 22 feet, the space occupied by eleven gabions. The traverses will be placed at intervals, of which the magnitude will be determined by the nature of the ground. On a descending slope, or in the neighbourhood of commanding works, the traverses must be nearer together than on an ascending slope. They must always be sufficiently close to afford cover.—It may be observed that there is no banquette on the outer side of the traverses, so that an enemy penetrating from the front could not use them against the defenders.

In the event of sapping under a commanding situation, it may be necessary to blind the sap, that is, to set up strong frames to be covered over at the top with fascines or sand-bags. In such a case, the sap should be made as narrow as possible.

123. The zigzag approaches, either by the flying or single sap, seldom by the former, are pushed on from the second parallel on the capital of the ravelin, as well as on those of the bastions, till they reach half way between the second parallel and the crest of the glacis of the work. Here it becomes necessary to establish demi-parallels, or portions of parallels, to contain strong guards to protect the further progress of the work, and to answer the defenders' musketry fire, which is done through loop-holes formed by sand-bags. These demi-parallels are either straight or curved, extending, so as to embrace the prolongations of the crest of the covered-way before the attacked works. At each extremity of the demi-parallels there is a battery of one or two howitzers, to enfilade and ricochet the branches of the covered way, and to keep down their fire as much as possible by tearing up their traverses, and clearing their banquettes.

These howitzer batteries are sunken, that they may not mask the batteries in their rear.

From the demi-parallels the sap is continued on the three capitals as far as it can be carried in a zigzag form; but when these zigzags become too multiplied, that is, when 100 yards of zigzag will not advance 33 yards in a direct line towards the place, the double sap must be resorted to. When the sappers on the three capitals have reached the foot of the glacis, they break into simple or single saps, and deploy to the right and to the left to connect their work together, in order to form the third parallel.

124. It is desirable to furnish all interior revetments of parallels or places of arms within 150 yards of the place with steps of fascines, so as to offer a ready means for the guard of the trenches to issue from them on a good front, and meet or pursue a sortie with their bayonets. During the execution of the third parallel the guard of the trenches must follow close upon the sappers, and those in the demi-parallels and second parallel must be prepared to meet sorties, which may now be expected to attempt the destruction of the work so near to their covered-way.

125. As soon as the third parallel is sufficiently advanced, batteries of 5½-inch small mortars are placed in it, generally on the capitals of the re-entering places of arms, but wherever they may be required, in order to shower grape and hand grenades into the re-entering places of arms, flanks and covered-way, so that by the combined fire of the batteries on the first parallel,—the howitzers in the demi-parallels,—and the mortars in the third parallel,—the defenders may be quite overpowered. The third parallel might have a greater capacity than the others, for it not only has less development, but the quantity of materials to be collected in it for further proceedings is very great. A strong and vigilant guard must fill the third parallel, and keep under the musketry fire of the place.

As the foot of the glacis is 8 feet below its crest, 19 below the ravelin, and 22 below that of the bastion, the third parallel will not mask the fire of the batteries behind it.*

126. The next operation is the crowning of the covered-way, for

* It now becomes necessary to seek for the defensive mines, if any are in existence, for it will be needless and destructive to push on the sap, until the ground below has been secured.

the purpose of establishing counter and breaching-batteries. It is for the commanding officer to decide whether this is to be done "de vive force," or by the more slow and safe mode of sapping. The motives which usually lead to the former are of a political nature; it may be requisite to abridge the duration of a siege. If these motives should be urgent, and the feeble fire of the defenders announce their weakness and discouragement, the attack by storm, or "de vive force," may be adopted, and the lodgment or crowning of the covered-way may be made by the flying sap. But if the besieged have redoubts and retrenchments in good order in his places of arms,—if there be good reason to suppose that the enemy can run up his remaining guns from behind protected traverses upon his barbettes, and shower canister and musketry upon the covered-way and glacis,—or if above all, it should be of little importance to hasten the fall of the place by one or two days, such an attempt should not be hazarded.

127. If the attack has been carried on under favourable circumstances, it is usual to reckon upon completing the third parallel about the twelfth night after opening the trenches. Should the safe mode of sapping regularly up to the crest of the glacis be determined on, single saps may be struck out from the third parallel, about 30 yards on each side of the capitals of the two bastions and ravelin attacked, and be carried forward in a curved direction, so as to meet about 20 yards up the slope of the glacis upon the capitals. These circular portions (S S) will be defiladed from the fire of the place, and from them double direct saps with proper traverses should be carried forward, till they arrive within 30 yards of the salient places of arms. Here if trench cavaliers are to be constructed, the double brigade of sappers again separate, one turning to the right, the other to the left, and describe an arc of single sap round the salients of the covered-way, till each has reached the prolongation of one of its branches; the saps are then made perpendicular to these prolongations and equal at least in length to the width of the covered-way; they are then terminated by a return of about 8 yards in length, which serves as an epaulement, defiladed from the works of the place.

128. These trench cavaliers are so traced, as to command the interior of the covered-way, to clear it of the defenders by their strong fire of musketry. They are rather too distant from it to be in danger of hand-grenades, which is the reason why 30 yards has been fixed upon from the crest for their position. They should be elevated about

8 feet above the glacis, which at 30 yards down is perhaps 4 feet below the crest. The construction of the trench cavaliers is condemned by many persons, on the ground that they greatly mask the howitzer batteries in the demi-parallel, and in some cases the enfilading batteries in the first parallel.

129. While the circular portions S S S, of the third parallel, and the trench cavaliers (if used) have been constructing, on the three capitals, a double direct sap, with traverses, will have been pushed from the third parallel, upon the capitals of the re-entering places of arms of the fronts attacked. On arriving within 20 feet of the crest of the glacis, the brigades again separate and become single saps, and proceed to connect their work on the right and left with other saps, that have in like manner been pushed on, to crown the neighbouring salients: thus the whole of the crest of the glacis of the fronts attacked, from T to U, is crowned. Preparations are immediately made for the construction of the counter and breaching-batteries, and for the formation of splinter-proof traverses. The counter-batteries are to counter-batter such of the remaining defences as command the ditches, and which may still be active, notwithstanding they must have suffered much from the previous enfilading fire of the guns, howitzers and mortars, from the various parallels; as these batteries must be subdued, ere the ditches can be crossed. The traverses on the branches of the covered-way that mask the fire must be either cut or blown away, that the guns may have a free range.

In those parts of the crowning of the covered-way, where it is necessary to place batteries of artillery, the trench in rear of the parapet should have a breadth of 24 feet; in other places not more than 12 feet; and traverses must be constructed wherever it may be necessary, in order to protect its interior from flanking fire, or afford shelter from bursting shells.

At the salient places of arms before the ravelin attacked, counter-batteries are also constructed, to silence the defences that flank the ditch of the ravelin. Thus the besiegers obtain a full command of all the ditches on the fronts attacked; and by keeping the fire of the defensive works under, the operation of crossing the ditches and taking possession of the breaches, becomes comparatively safe.

The besiegers' counter-batteries before the salient of the ravelin, having obtained the superiority over the artillery of the defence on the faces of the bastions, become breaching batteries; and the

ditches of the ravelins being entirely under their command, the besiegers may descend into them when they are dry, and sap along their bottoms towards the breaches.

Besides the counter-batteries, batteries are constructed on the crowning of the covered-way, opposite to such portions of the faces of the works as are selected, for the formation of breaches in the revetments.

The revetment will be most easily and effectually breached by cutting it in an horizontal line, near the bottom, when the ditch is dry, and level with the water when the ditch is wet, and at regular intervals of six or eight feet in vertical lines. To effect these cuttings, the guns should fire with the full service charge of powder. When the portion of revetment to be breached has thus been divided into sections, salvos should be fired with reduced charges, to shake and bring the masonry, tumbling in masses, into the ditch.

After breaching the walls, should the soil of the rampart stand stiffly, large shells filled with powder, having long fuses, should be thrown in, which will act as fougasses, and bring it down. The breaching batteries must be in action by night as well as by day, to keep the enemy from stockading the breach, or otherwise rendering it impracticable.

Should any case occur, in which the revetment cannot be seen sufficiently low down to be effectually breached from the crest of the glacis, the breaching battery must be established on the terre-plein of the covered-way.

130. The fire of these batteries on the crest of the glacis, assisted by riflemen from loop-holed cover of sand-bags, when aided by the unceasing, and concentrated fire of heavy artillery from the first and perhaps second parallel, followed subsequently by the fire of the powerful howitzers on the demi-parallels, and from the mortars on the third parallel—as far as all these are able to aid, from being partially masked by the crowning of the covered-way,—must and will effectually keep under the fire of the defenders. The combined fire will prove so overpowering, tearing up and destroying everything opposed, that the operation of seizing the other works will be far less destructive than is at first sight imagined.

131. While these batteries on the crest of the glacis are being constructed and in full operation, the descent into the ditch is being effected by a subterranean gallery, whenever the counterscarp is suffi-

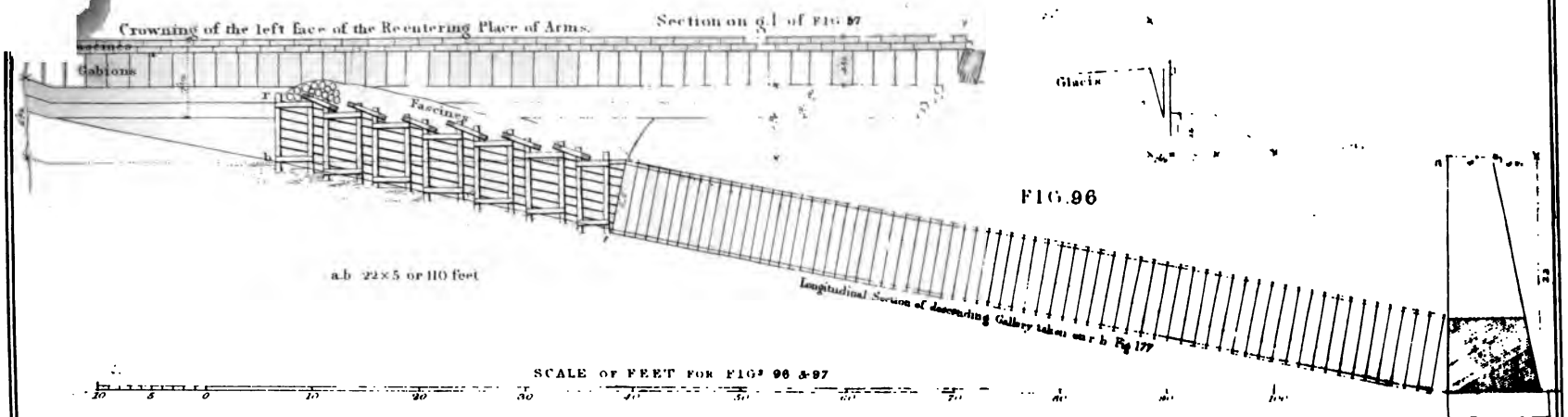


FIG.96

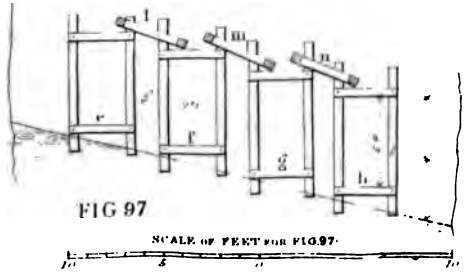


FIG 97

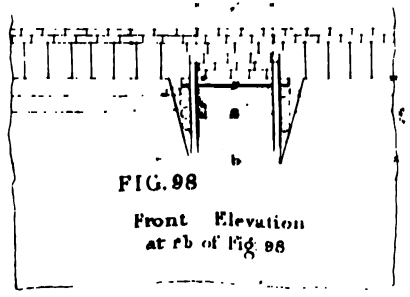


FIG.98

Front Elevation
at rb of Fig 98

Face page 103

ciently elevated to preserve a covering of 5 feet between the top of the gallery, and the terre-plein of the covered-way. This thickness, at least, miners consider to be absolutely necessary overhead, in driving a gallery in ground of ordinary tenacity. The dimensions of this gallery—the section of which (fig. 96) is taken from *g* to *l*, of fig. 57,—will depend upon the use to be made of it. Should artillery be necessary to reduce inner works, such as retrenchments, it must pass through the gallery, which must be large enough for this purpose, viz., 7 feet wide and 6 feet 6 inches high; but 6 feet high by 4 wide may serve simply for the passage of troops. The gallery usually opens at the bottom of a dry ditch, or 15 or 16 inches above the water of a wet ditch. It should have a slope of about five times its height, that is, *a b* (fig. 96) is five times *a c*. It usually commences from some trench or sap, a little in the rear of the crowning of the covered-way, or in the trench by the face of the re-entering place of arms, as in figure 57.

The sides of the galleries of descent are supported by frame-work, called blind frames.* These are something like door frames, with projecting ends, and being placed in the ground on the opposite sides of the gallery, are kept apart by similar frames placed across at the top. Behind the frames a row of fascines should line the sides, to keep the earth from falling in. These frames are succeeded by mining cases, as soon as proper cover is obtained above. In shallow or wet ditches, where there is not a sufficient quantity of

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* These frames, *e f g h* (fig. 97), are placed on each side of the intended gallery, at about 1 foot apart: they are usually 5′ 4″ high and 2½′ wide in the clear; two rows of these frames are placed parallel to each other at 4, 5, 6, or 7 feet apart, according to the width of the gallery. A roof is formed by a set of corresponding frames that rest upon the top sills of the side frames, as seen at *l m n*: this section shows one side of the arrangement, or one row of the frames: the little shaded ends indicate the sections of the long parts of the frames that cross the gallery at the top. In fig. 98, *r b* shows the first frame, which is succeeded by others, carried on to *i d*, covered over at top with three layers of fascines, some earth, and then green hides of animals stretched over all, to prevent their being set on fire. When this blinded descent has advanced so far that a solid covering of 4 or 5 feet of earth can be obtained, a regular gallery is begun with mining-cases, as seen at *i d*, and continued to *c*, where the miners break through the counterscarp revetment. The descent is commenced by excavating the sloping ramp *b i d*, and is carried on as before stated until there is a sufficient mass of earth above to allow the regular mining-cases to be fixed; all in the rear of this is blinded. Fig. 98 shows an elevation of this descent at its entrance *r b*, the lines indicated at S being the tops of the frames and cases.

earth above to form a regular gallery like that of a mine, it is sometimes necessary to carry this blinded descent all the way to the counterscarp. These descents are usually driven under a traverse in the covered-way, to obtain as much cover as possible above from vertical fire.

In all cases of descent by gallery, when the miners reach the back of the counterscarp, they pierce through the wall, by forming an arched passage of the required dimensions.

It is usual to make recesses on each side of the extremity of the gallery, behind the revetment, in which the materials for crossing the ditch are collected. These chambers are of great importance to the engineer, in the difficult operation of crossing a wet ditch.

132. When the fire of the defensive works has been fully subdued, and it is intended to assault the breaches as soon as they can be made, instead of these laborious descending galleries, three or four shafts may be sunk under the terre-plein of the covered-way, immediately opposite the breaches, and charges of powder lodged in chambers at the bottom: the explosion of these will throw in the counterscarp, and join the rubbish (as at *x x x*) to that of the breach in the escarp, the explosion being the signal for the storming parties to advance.

133. When the ditch is dry, and a descending gallery has been constructed, the passage of the ditch consists of an ordinary sap pushed from the opening in the counterscarp wall to the slope of the breach (as at *l*, Fig. 57), and, when necessary, it is carried on to crown the summit of the breach.

If the ditch be full of water, and the locality favours its being drained, every means must be used to break the batardeaux, to cause the water to flow away entirely or in part. If none of the batteries can see the batardeaux, the sluices must be sought for and destroyed by shells, or by mining.

Should the assailants be unable to breach the batardeaux or to destroy the sluices, a bridge or causeway must be thrown across. This is one of the most difficult operations in a siege. The bridge or causeway, with its epaulement, is constructed with pontoons or casks, or in their absence, with fascines, hurdles, gabions, and sand-bags, openings being left in the causeway to allow the free flowing of the water, if it be a running stream, or if it can be made so by the defenders. A wet ditch may sometimes be crossed by a raft of sufficient length, which should be constructed along the counterscarp, and attached by one end to the

bottom of the descent. The raft is then allowed to swing round with the current, if there be one, or is rowed or pulled round, if there is not one, so as to form a connection across the ditch with the breach.

The following experiment for crossing a wet ditch was successfully tried at Chatham by Sir Charles Pasley:—Two hundred large casks were prepared, with their heads taken out; they were lashed by fours, end to end, so as to form hollow piers, about 18 feet in length, of unequal diameters, in consequence of the unequal size of the casks. Each pier was launched in succession from a great gallery, representing that of the counterscarp, in a regular siege. These piers had guys at each end, by which they were hauled round into their intended position, and there sunk by means of sand-bags. After this, the intervals between the upper tiers of casks were filled in with long fascines, and others were laid over these at right angles, till a general level was obtained, when strong skids were laid over all, and a 24-pounder, on a travelling carriage, was dragged through the gallery, and passed along these skids to the other side. In this manner, a piece of water, representing a wet ditch, was bridged over with ease and comparative expedition. This experiment was afterwards tried with full success in the Mast Pond of Chatham Dockyard, where a very strong current was produced, much stronger than could occur in the ditches of any fortified place. It is stated, that there was no perceptible depression in the bridge as the 24-pounder passed over.—The same experiment was tried with common gabions, lashed together, end to end, in like manner, forming hollow piers or cylinders, which were similarly sunk one over another until the upper layer rose above the water, and were covered with fascines and skids. These, also, bore a 24-pounder, which caused a depression of more than 6 inches in the part over which it was passing. The gabions were very weak and old.—The piers of casks were fastened as follows: on being placed end to end, staples were driven into each cask, about 10 inches from their ends, in three equi-distant parts of their circumference; strong spun-yarn, connecting the staples, lashed the four casks together. Six or eight bushel sand-bags were necessary to sink each pier with ease, yet without making it sink too rapidly. To get them into the water, they were launched on ways made of planks. In making the gabion bridge, each pier consisted of four gabions lashed end to end like the casks, by spun-yarn, at three equi-distant points of the circumference. These were not loaded to make them sink. It was found, from the irregu-

larity of their surface, that the second pier merely forced the first out from the bank to make room for itself; the third the second, and so on, until tiers of gabions connected the two scarps. On rolling other piers on the top of them, the lower ones sunk to the bottom, and fascines and brushwood were laid in the intervals of the gabions to form a level surface.

134. On the completion of the passage of the ditch, the breaching batteries should render the breach as gentle and practicable as possible for the assault, either by round shot or shells, as required. But if the ravelins have redoubts,—or if the bastions be retrenched,—it will be necessary to carry the attack on further, by pushing a regular sap up the breach, and by forming a lodgment within the work, for subduing the remaining defences.

Preparatory to making the lodgment, a great quantity of materials must be provided, such as gabions, fascines, and sand-bags, and also a number of entrenching tools, which should be carried as far forward as possible, without encumbering the trenches, and be piled on their reverse slopes. Care must be taken that all the lodgments, from which it is possible to fire on the part to be attacked, be in a perfect state; and that the batteries of guns and mortars be in readiness to open. The officers commanding in the batteries and lodgments should receive detailed instructions how they are to act in obedience to the signals which may be made.

The signals may be made by a flag elevated on the lodgment of the covered-way, at a spot where it can be readily seen from all the batteries and lodgments. Everything being ready, the infantry should place their muskets through the sand-bags laid for their protection on the top of the parapets, and every one should wait in silence for the signal to open his fire, when the flag is hoisted, and to cease firing on its being lowered.

Thus prepared, two or three sappers should ascend the breach, not up the centre, but on its right and left, next the end of the broken wall, where cover may usually be found between the part of the revetment which remains standing, and that which has been beaten down. The sappers should lodge themselves in these hollows, throwing the rubbish down, but working upwards; and procuring cover for two or three sappers, who should be sent to their assistance, the whole being prepared to leave their work on any advance of the enemy. Should that occur, as soon as the sappers are off the breach, the signal should

be made, and all the batteries and lodgments should instantly open a heavy fire on the enemy, who cannot remain under it, but will quickly disperse. As soon as that is perceived, the flag must be lowered, and the sappers again sent forward, resume their work, and push it on as much as possible, abandoning it when the enemy make their appearance, which may occur a second and even a third time. Each time, however, that they do come forward, all the lodgments and batteries, even those of the covered-way, must resume their fire, which cannot fail to drive them back, and give opportunity to establish the lodgment. Probably it will not be till the second or third time of returning that the garrison will spring their mines (if there be any), which may be considered an infallible sign that they are giving up the work. These mines are not likely to be attended with any great effect, as they may be sprung at a moment when the workmen are not on the breach. In the meantime, the sappers will have prepared some cover in the excavation, which, when completely ready, and not till then, must be occupied by small detachments; but as soon as the garrison abandon the work, the lodgment must be made openly in the breach, and be well secured along the whole excavation, but not beyond it. Afterwards, the work must be extended to the right and left along the rampart by saps, forming a portion of a circle which will occupy all the terre-plein of its flanked angle: from thence it will be carried along the two faces of the work, till everything is duly prepared to force the retrenchment at the gorge. In like manner, if the bastion be retrenched, the sap must be carried up the breach, and a lodgment formed within the flanked angle, the fire of which, supported by that of the batteries of guns, howitzers, and mortars in its rear, will overpower the remaining feeble defences, and enable the assailants to advance to the assault, should the besieged risk this fatal proceeding.

135. It is considered a maxim that a fortified place must inevitably fall before a properly-executed attack by a force of adequate strength. This arises conjointly from the action of several causes. 1st. The advantage of position, enabling the besiegers to destroy the artillery fire of the defenders with an equal, if not an inferior number of guns. 2nd. Their power of recruiting, from time to time, their strength in men, materials, and ammunition, so that their expenditure in these matters is practically unlimited. 3rd. The power they possess of opposing, on every point, a superior force to that of the garrison.

In a town of the utmost magnitude, every supply is limited; gun after gun, and platform after platform, may be replaced; fresh materials may long be found to repair every casualty, and even fresh men may for some time be forthcoming to relieve those disabled. But finite means must diminish by use. The largest magazines will be ultimately expended. Each succeeding day of a siege empties them in a two-fold proportion, and nothing can be procured from without to replenish them. At length, after a certain period of resistance, the garrison find all their resources exhausted, whilst the power of the attack is hourly augmenting, and only save their lives by a capitulation.

Next to a sufficiency of men, of artillery, and of ammunition, an abundant supply of materials and stores will be found the most important aid in reducing a place with certainty and little loss. Such an abundance will facilitate the advance of the approaches, and save the lives of the troops at every step. Indeed, there is nothing more certain than that the reduction of a fortress must be paid for in materials or men, and that to save the one, the other must be freely sacrificed.

Whatever be the quantity of stores, or however great the mass of materials found to be required on a calculation of the details of the works, they should all be on the spot previously to breaking ground, or their arrival be assured at given periods of the attack. Delay, loss of life, and disaster are the infallible consequences of any irregularity in the receipt of materials during a siege.

136. The quantity of materials required for any given nature of operation may be calculated with the utmost exactness, as soon as the plan of attack has been laid down. The mass of gabions and fascines, by a measurement of all the lines of the trenches from the second parallel inclusive; the breadth of the ditch, the front and height of the cavaliers of the trenches, the numbers and extent of the several lodgments, &c., &c. After making the calculation with accuracy, it will be necessary to add one-half to the amount, as very considerable numbers of both fascines and gabions, will be destroyed in the carriage; whole rows must occasionally be replaced, and many uses will be found for them, in the progress of the work, which cannot be anticipated. Next come the materials for the batteries, the gabions and fascines for the cheeks of the embrasures, the sand-bags for their interior revetments and traverses. Then sand-bags to cover riflemen, of which a large number will be required. To these quantities a

large addition must be made, as sand-bags are a reserve store of incalculable value, and the mainstay of many English operations.

In a similar manner, the quantity of scantling and plank required for the galleries of mines, platforms, splinter-proofs, &c., should be calculated, and a very large addition made to the amount for unavoidable accidents and unforeseen labours.

The entrenching tools should be, at least, in the proportion of three to one of the most numerous working party likely to be employed. Pickaxes and shovels cost little originally, and are not necessarily expended with use, like shot or shells. One hour's firing from the batteries at a siege costs more to a state than the value of all the entrenching tools with an army.

137. The number of pieces of ordnance required for the attack of a fortress has not so much reference to the number of pieces mounted on its ramparts, as to the construction of the works themselves which they are intended to defend; for the besiegers never willingly oppose artillery by a direct fire, but generally contrive, by a skilful disposition of their trenches and batteries, to render one piece of ordnance in the attack superior to several in the place. Thus, for instance, three guns firing à ricochet from any convenient point, within proper distance, on the prolongation of a face or other line without traverses, will dismount any number of guns,—say 10 or 12,—which may be mounted upon it; or, if the line be traversed, they only require the aid of shells from two or three mortars to ensure the same effect; and such a position for the besiegers' batteries may be found on the prolongation of most of the lines of ordinary works.

There will, however, be, in all irregular, mountain, and maritime fortresses, many faces against which an enfilade fire cannot be made available, such as portions of works formed with a considerable curve, or where, by a skilful disposition of the defensive lines, their prolongations are made to fall on situations where batteries cannot be erected; as a hollow, an inundation, a river, the sea, or that they are made to intersect other portions of the work which cover and conceal their ramparts; or where the works stand on very great elevations, or are naturally shouldered in by higher ground on their immediate flanks.* In these cases the ordnance of the place must be silenced by direct

* This was remarkably the case in the siege of Sebastopol, where scarcely a single line of the Russian works could be enfiladed by the besiegers.

fire from the besiegers' trenches, and such fire, to be effectual, ought to be superior in weight and quantity to that which it is intended to silence.

A battery thus firing from the trenches has this advantage over the batteries of the place, that its undivided attention can be given to one object; whereas the defensive ordnance must occasionally be diverted to efforts to arrest the progress of the works of the attack. Therefore, gun for gun, and mortar for mortar, the besiegers would generally succeed in overpowering the fire of a place; but where ordnance can be procured, double the amount of that to be silenced by direct fire should be brought into the trenches, which would effect the object in far less than half the time.

Therefore to carry on the attack of any place, however fortified, with speed and little loss, there should be provided to be put in battery immediately after breaking ground, an equal or if possible, double the number of guns to those in the place which it may be found necessary to oppose by direct fire; and from three to five heavy guns or howitzers for every line bearing on the attack, subject to be enfiladed. Five pieces to be used against the principal faces and longest lines, and three against the shorter lines. To render their fire effectual, it is absolutely necessary in addition, that two or three 8 or 10-inch howitzers should be planted in each of the principal batteries to destroy the defensive traverses, and reach into such parts of the enfiladed lines as may be sheltered from the ricochet of guns. This will in future be much more easily and certainly effected by shells with percussion fuzes fired from the rifled enfilading guns.

If there be a covered-way, two or three howitzers of the heaviest class, in addition to the above, will be required to sweep each of its faces, when the approaches arrive within short musket shot of the salients; and three or four pierriers or mortars, charged with small balls, to overwhelm the defenders of each of the re-entering places of arms, when the approaches arrive at 60 or 70 yards from the covered-way.

Such a provision of ordnance will serve to gain possession of the covered-way of any ordinary fortress; but for the further prosecution of the attack from that point, other fifty pieces of ordnance, firing with the full charge, should be provided.

The recent improvements in artillery will most probably enable the besiegers effectually to clear the covered-way by the fire of their en-

filading batteries in the first parallel, and obviate in a great measure the necessity for the construction of advanced batteries, except for the purpose of breaching the escarp revetments.

The exact number of pieces of ordnance required for the reduction of a fortress, can only be distinctly ascertained by the joint labours of the heads of the artillery and engineers' service after the plan of the attack shall have been decided; but as some approximation is necessary for the previous outfit, it may be stated, that the smallest number of pieces, which any calculation will admit for the reduction of a front with a ravelin, is 60 heavy guns, 20 howitzers, 22 mortars, and 16 pierriers; and that to carry on the attack with due convenience and vigour, the heavy guns should number 120, the mortars 30, and the pierriers 16.

138. Quantity of ammunition. As the enfilading batteries must continue open till the approaches arrive at the crest of the glacis, and the mortar batteries during the whole period of the attack; the ammunition for the service of these batteries, necessary for a siege of a given duration, depends in great measure on the number of rounds fired from each piece in a given time.

At the commencement of a siege, the enfilading and mortar batteries should fire to produce their utmost effect; but after twenty-four or thirty-six hours' severe firing, the traverses will be demolished, the platforms broken, and the artillery on the ramparts disabled; after which only such fire need be maintained as will prevent working parties of the garrison repairing the injuries sustained, or bringing up fresh ordnance. For this purpose, great precision and an equal fire day and night, will be required, and each piece should fire a regulated number of rounds per hour. As the effect of each shot must be watched, the charge accurately apportioned, and the utmost attention paid that the piece be duly regulated each time; and further, as there is much merit and real utility in expending no more ammunition than is absolutely necessary to effect an object, it would perhaps be better that the fire of guns à ricochet were limited to 100 rounds in the twenty-four hours.

The mortars in battery might probably be used with advantage to the extent of 120 rounds per day throughout the siege.

Batteries to breach fire as quickly as they can with precision, which may now be estimated at 25 to 30 rounds per hour; but as such rate of firing injures the guns, and further, is little likely to be maintained

where opposed by musketry, the average rate for breaching may be stated at 20 rounds per hour for the period of daylight. On these data the precise quantity of ammunition of every nature required for the reduction of any place, may be calculated as soon as the plan of the attack has been laid down; but as that cannot be fully decided till after the investment, some approximation to the calculation is required for the previous outfit. For the attack of an ordinary front, it will be found sufficiently accurate to provide 60 rounds of shot per gun, and 60 shells per mortar, on the full proportion of ordnance, above mentioned, for each day the attack is calculated to last; or 1,200 rounds per gun and mortar, independent of shells for the howitzers, for a siege of twenty days.

For each pierrier there should be provided 400 rounds of half pound and one pound balls; and also a considerable proportion of case and grape-shot for all the natures of ordnance, and at least 15,000 hand grenades.

In the late siege of Sebastopol the position of the Russians extended for nearly fifteen miles. The besiegers' trenches were fifty-two miles in length; they comprised 109 batteries, armed with 806 pieces of ordnance. The expenditure of ammunition, 1,500,000 rounds, was measured by 1,000 tons a day, and even in the most advanced batteries were placed guns and mortars of a calibre seldom before used at a siege.

The trenches were open 334 days, and the batteries 327 days.

139. The determination of the number of men necessary to carry on a siege with vigour is founded on principles always remaining the same, but varying in certain contingencies, of which the commander of the army is alone capable of judging. There must be working parties and bodies of troops to defend their operations—the former must be sufficient to complete the necessary work in the given time—the latter must be strong enough to repel any force which the garrison may be able to bring against them. Both the working party and the guard will require rest, which should, if possible, extend to 18 out of the 24 hours; so that in this arrangement, four complete sets, or reliefs, would be required daily. Three reliefs may be sufficient for the guard for a short service, but four, when circumstances permit, will be found much better, and four will be necessary for the working party. The calculation may then be as follows:—Guard of the trenches, three-fourths of the garrison, three reliefs; working

party in number depending upon the trace of the work to be attacked; but for the sake of calculation, let the operation against a common front of 360 yards be assumed. Then the length of the first parallel, and one line of approach to it, which should always be opened on the night of breaking ground, measures 3,800 yards, which, at four feet apart, requires 2,850 men to line them, and that number will therefore be the strength of the first night's working party. The second night the same number of workmen will be required; and what with the service of the artillery, and the transport of materials, but small deductions can be made from their strength till the completion of the second parallel. For the remainder of the siege much fewer will suffice; therefore, by arrangement and a little extra fatigue on the first days of the attack, the working parties may be averaged at one-third less than the party of the first night, or, in round numbers, 2,000 men.

For regimental and camp duties, pickets, escorts, with stores and provisions, &c., the proportion of the army required will vary according to the hostility of the people in whose country the war is carried on, and it is one of the contingencies to be regulated by the general commanding: but being fixed, their reliefs must be equally regular with the others. For the sake of calculation it will be here stated as one-tenth of the whole army.

On these data, the amount of an army required for the vigorous siege of a place, with a garrison of 5,000 men, would be—

Guard of the trenches, 3,750, at three reliefs -	11,250
Working parties, 2,000, at four reliefs - - -	8,000
Total - - - - - - - -	19,250
Duties of the army, one-tenth of the above total, at four reliefs - - - - - - - -	7,700
Total, independent of sick and casualties -	26,950

From this calculation it is evident, cæteris paribus, that the more numerous the garrison, the smaller the besieging army need be in proportion to it; for the attack of a similar front or fronts of fortification is little different, whether the place contain a garrison of 5,000 or a garrison of 10,000 men: the guard of the trenches and the other duties increase proportionately, but the work does not.

Hence it is that the most celebrated commanders and best engineers are agreed, as a general principle, that the besieging army should vary in its proportion to the strength of the garrison; and, as an approximation, have fixed that proportion at 5 to 1, when the garrison consists of 15,000 men; 6 to 1 when of 10,000; 7 to 1 when of 5,000; 8 to 1 when of 3,000; and in still greater proportion when it consists of a less number.

If there be any cavalry in the place, the guard of the trenches should be supported by a body of cavalry equal in number to the cavalry of the garrison, with a reserve of one-half more posted at the mouth of the trenches; for, as cavalry act invariably on the flanks of the trenches, the cavalry guard on each flank ought to be prepared to oppose all the cavalry in the garrison; and by such an arrangement, this will be the case; the body of one-half held in reserve being in a situation to support either flank, and make it of equal strength with the whole number in the garrison. The sortie on the 19th of March, 1812, from Badajoz, is a remarkable instance of how much a few cavalry may effect if not opposed by cavalry—forty or fifty men on that day having carried confusion into the very depôts of the artillery and engineers, and made officers prisoners at nearly 2,000 yards from the place.

These calculations do not apply to peninsular fortresses on a restricted front; but in all open situations an army formed on the above calculation would, at the end of a siege of a month's duration, be greatly fatigued. It is not, however, intended to convey the impression that a siege should never be undertaken unless with a force thus proportionately greater than the garrison, but merely to point out, where choice exists, the best rule of proceeding. There are exceptions to all general rules; genius will sometimes supply the place of number, and necessity oblige where calculation condemns.

CHAPTER V.

THE DEFENCE OF FORTRESSES.

140. The Defence of a Fortress is more difficult than the attack, and as it consists mainly in combatting inch by inch every advance and operation of the attack, and in delaying as far as possible the progress of events which cannot by any human means be entirely arrested, it requires in a higher degree the exercise of endurance, fortitude and courage.

The Governor of a besieged town has to encounter a specially arduous task, and few men are fitted for the position. In addition to the responsibilities and duties of the actual defence, it is his duty to guard against surprise from without, and treachery from within, and he is frequently obliged to restrain or subdue a disaffected or a turbulent population,—impatient of the hardships and suffering they are necessarily called upon to endure.

It is the duty of the Governor, in times of peace, to become thoroughly acquainted with every detail of the fortress in his charge. He should survey with care and become personally conversant with every feature of the ground in the immediate neighbourhood, and carefully consider every facility for attack and defence, which the nature of the position may offer. He should study the levels of the country, the course and fall of the streams and rivers, and be provided with plans for inundating the country, where it can be done, without loss of time. He should preserve the fortress in good repair, and keep the country round, to the distance of cannon shot, clear, as far as circumstances permit, of all hedges, ditches, trees, hollow roads, and houses, nor suffer anything to be done advantageous to the approach of an enemy.

141. At the first appearance of a probability of an attack, an ample supply of provisions must be collected, and an adequate store of ammunition provided, to meet the requirements of a protracted siege. The works must be carefully surveyed and put in order, the covered-way be palisaded, and the wet ditches cleared of mud. The galleries of mines should be examined and extended as far as possible, and any houses or buildings within the rampart which might be detrimental to the defence must be demolished. The hospitals should be put in order, and provided with every necessary for the sick and wounded.

The magazines require especial care. They are always bomb-proof buildings; but to secure them from the effects of a number of shells, they must be kept well covered with 7 or 8 feet of earth, and blindages be provided for the doors. The whole quantity of powder should be distributed in several magazines, that an accidental explosion may not altogether cripple the defence.

142. The place having been invested, the first object of the defenders is to discover the side which the besiegers intend to attack, and they must omit no means of ascertaining it. Meanwhile they will impede as far as possible the reconnoitring parties of the enemy, who will be seeking for weak points of the fortress on which to make their attack.

143. So soon as it is certainly known on which side the attack will be made, retrenchments must be immediately prepared in the bastions and ravelins of the fronts attacked. At this time they can be readily made; at a later period the pressing demands on the exertions of the garrison, and the disturbing effects of the shot and shell of the besiegers will greatly increase the difficulties attendant upon, if not altogether prevent, their construction.

144. The garrison must now take every measure to prevent the establishment of the first parallel. The heavy guns mounted en barbette on the ramparts of the place, and the field guns from the covered-way and other out-works will keep up a vigorous fire on the besiegers, while light balls are thrown from mortars to discover the working parties and their guards. As soon as the trench and parapet of the first parallel has been completed, the defenders will cease to fire on it, as no object can be gained by a continuance of their fire at all commensurate with the expenditure of ammunition.

145. The garrison must now endeavour by all means in their power

to interrupt or prevent the establishment of the besiegers' enfilading batteries in the first parallel. Should these batteries, notwithstanding all the opposition of the garrison, have been permanently established, the most strenuous efforts should be made to overwhelm them by the strongest artillery fire which can be brought against them, a proceeding fully accomplished by the Russians several times in succession during their defence of Sebastopol. Failing in this, the defenders will have little opportunity of obstructing the steady progress of the siege until the passage of the ditch and the assault of the breaches.

146. The besiegers' batteries on the covered way having been permanently established, the defenders will direct their attention principally to completing their retrenchments and traverses, and delaying the advance of the besiegers' saps. The defenders will frequently be able to make counter approaches to take in flank the works of the besiegers. The trenches and batteries made for this purpose will be similar to those constructed in the attack. Care must be taken to direct them in such a manner as to be enfiladed by the works of the place. The counter approaches of the Russians at Sebastopol extended 17 miles in length.

147. The defenders will now delay as far as possible, and in a similar manner to that employed in the case of the first parallel, the establishment of the second parallel, so as to force the besiegers to complete this work by the slow process of the ordinary sap. Blinded batteries should be constructed in the salients of the bastions and ravelins to carry two or three guns to bear directly on the approaches on the capitals of these works.

Should the siege have been conducted with proper vigour, the second parallel will be established in spite of the most strenuous efforts of the besieged, provided their artillery has been adequately subdued.

The advance of the approaches from the second parallel must be retarded and impeded by a continuous fire of small arms, which should be kept up by the defenders from their most advanced works, and from rifle pits in front of them, while the working parties in the heads of these approaches may be harrassed and kept on the alert by constant sorties of small bodies of troops.

148. Sorties should be occasionally made throughout the whole course of the siege, as, although they will generally be repulsed with loss, the labour and fatigue which they occasion to the enemy far

more than compensate for the loss to the defenders—inasmuch as they oblige the besieger to keep the whole of his works adequately guarded, night and day, always ready for and expecting an attack, thus entailing upon him and his troops a constant and harrassing watchfulness, which becomes perhaps the most tedious and arduous duty of a siege.

Small mortars should now be placed in position in the covered-way, to shower pound shot and hand-grenades into the parallels and approaches.

149. The approaches will now steadily advance and the third parallel be formed by the ordinary sap. As soon as this is effected, the defenders must make every preparation to repel the assault of the covered-way, which the besiegers may attempt at any moment. All the works commanding the covered-way should be lined with riflemen, who should be provided with loop-holes of sandbags or other secure cover, from which they may safely fire upon the assailants of the covered-way.

150. The covered-way having been crowned, the construction of the breaching batteries must be retarded by continuous rifle firing, and retrenchments must be commenced to sever the breaches which will now speedily be made in the escarp, from the other parts of the fortress.

When the breaches have been actually made, every means must be taken to repel an assault. 1st. The rubbish falling into the ditch should as far as possible be removed every night, which will render the breach impracticable or at any rate difficult. 2nd. Retrenchments behind the breach must be so arranged as to give a concentrated cross-fire over the breach and the ground within it. 3rd. Shells, shot, hand-grenades, &c. should be prepared in quantities to shower upon the assailants at the moment of the assault. 4th. Chevaux-de-frise of sword blades, pikes or beams should be placed across the breaches in positions as sheltered as possible from the enemy's fire. 5th. The breaches should be mined, but these mines must only be sprung as a dernier resort when a successful enemy is crowding on the breach, as though they may destroy a large part of the assaulting column, and may consequently repulse the immediate assault, they cannot fail to render the breach more easy and therefore less capable of defence against a subsequent assault.

There are many instances on record of successful defence of a

breach, especially when the assault has been made before the breaches are practicable and easy, and the repulse of an assault when it has taken place has always occasioned an enormous loss to the besieging force, and has sometimes obliged them to relinquish the attack.

CHAPTER VI.

DEFENCE OF FIELD POSITIONS.

151. It is the first duty of every officer to preserve the lives of his men, and this duty he cannot fulfil unless he is able by the construction of field works, of a simple character, to make the most of the local advantages of any post or position which he may be called upon to defend.

In any particular case, the plan of operations to be carried out will depend upon a variety of circumstances. The following considerations are generally applicable and require special notice:—

1st. The period likely to elapse before the position is attacked.

2nd. The number of troops by whom the position is to be held.

3rd. The number of men available for the construction of the work, and the nature of the materials at hand.

On the first of these considerations, namely, the period likely to elapse before the position is attacked, will in a great measure depend the character of the work, that is the height and thickness of the parapet, depth and width of the ditch, and the nature of the obstacles which may be added,-as no matter how strong the working parties may be, only a certain amount of work can be executed in a given time, and a work of even feeble profile thoroughly complete will be capable of a better defence than a stronger work only partially executed.

The extent which it may be desirable to give to the work will be limited by the number of men available for its defence. There must, at least, be sufficient to man the whole of the parapet, and a reserve, in addition, is almost essential. The length of crest line measured in yards, must not exceed half the number of men allotted for its defence.

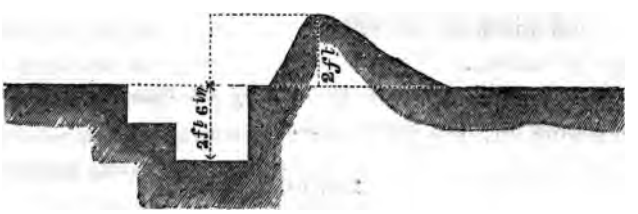
When either labour or materials are scarce, it may be necessary to reduce the profile, and to contract the extent of the work below that which would be desirable under other circumstances; but in this case the details should be so arranged as to admit of subsequent additions, should circumstances allow it, so as to bring the whole work to that condition which might have been desirable, though unattainable in the first instance.

When time, labour, and materials are abundant, a good parapet and ditch should always be made to secure the defenders. The dimensions and construction of such a parapet are described in article 17, chap. II.

152. The construction of a complete parapet requires more time and labour than are always disposable in field operations, and cover can be obtained for a limited number of men in a more expeditious way. Thus a man will be equally protected from an enemy's fire, by standing behind a parapet 6 feet high, or in a trench 3 feet deep, with a bank of earth 3 feet high in front of him. Now to dig a trench 3 feet deep, and throw the earth to the front so as to form a bank 3 feet high, may be performed by the same number of men in at most $\frac{1}{8}$ of the time required for the construction of a complete parapet 6 feet high.

A trench and breastwork then will be generally used when the time is limited, and when cover and not the creation of an obstacle is the principal object of the work. (Fig. 98) represents a section of the

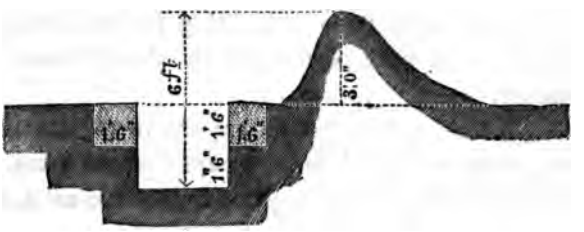
Fig. 98.



slightest work of this nature which can be of any service. Here a trench $2\frac{1}{2}$ feet deep is dug, and the earth thrown to the front forms a rough parapet 2 feet high. The trench can contain one rank only, and the total cover being $4\frac{1}{2}$ feet high, the men will not be safe except when sitting or stooping. A trench and breastwork of these dimensions can be completed in about $1\frac{1}{2}$ hours. The next section

Fig. 98) is more serviceable; the total height of cover in this case is 6 feet. The men will be safe therefore so long as they remain in the

Fig. 98.



trench, which provides room for one rank only at a time. The completion of this work would require about 8 hours.

Fig. 99 is a section of a breastwork and trench of a capacity sufficient for most of the purposes for which works of this nature are usually required. The trench is wide enough to contain two ranks of men at the same time, and affords cover 6 feet in height. Such a work can be executed in about 5 hours.

Fig. 99.

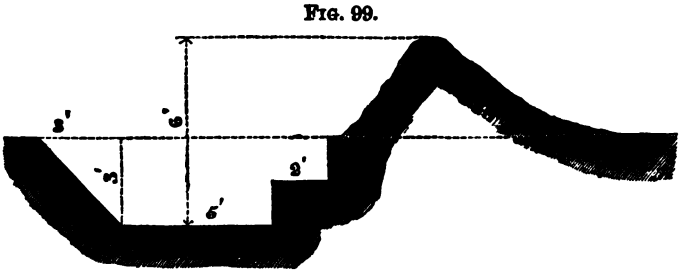
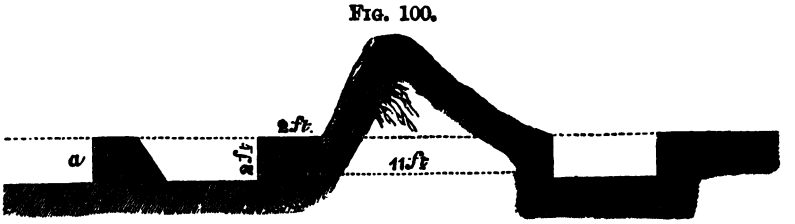


Fig. 100 is a profile adapted to marshy or rocky situations where shallow trenches only are practicable.

Fig. 100.



This work can be constructed very rapidly when labour is abundant,

as two working parties, one in front and the other in rear, can be employed at the same time.

153. The work to be performed then will generally be the excavation of a trench or ditch, and the formation of a parapet or breastwork, with the earth thrown out of it. It will in most cases be executed by the troops themselves, though sometimes labourers may be obtained and the former be saved the exertion.

In constructing a simple trench and breastwork, one row of workmen only can be advantageously employed at the same time, and it will be found desirable to place them 6 feet apart; as at this distance each man can use his arms freely, without interfering with or injuring his neighbour. When the saving of time is of more consequence than economy of labour, the diggers may be placed 4 feet apart, and the completion of the work will be accelerated, though not in proportion to the increase in the number of workmen.

An ordinary labourer or common soldier can excavate one cubic yard, *i.e.* 27 cubic feet in any but the hardest soils per hour; and can continue working at this rate for 8 hours. Should the soil be loose or sandy, so that the pickaxe is seldom required, this estimate may be nearly doubled.

The trench or breastwork will be completed in the time in which each man will finish his portion, that is, a portion equal in length to the interval between any two adjacent diggers: therefore the number of hours will be equal to the number of cubic yards in such portion. Whence the following rule is at once obtained:

To find the time required for the construction of a trench or parapet, in ordinary soil—

Multiply the area of the section of the trench in square feet by the interval between the diggers (not less than 6 feet), and divide this product by 27, the quotient is the number of hours required for the construction of the work.

Conversely to find the area of the section of the trench or breastwork which can be executed in a given time—

Multiply the number of hours by 27, and divide the product by the interval (in feet) between the diggers, the result will be the area, in square feet, of the section of the trench or breastwork.

154. It will frequently happen that cover can be speedily obtained, and positions rendered defensible in a very short time, by taking advantage of the hedges, ditches, or walls, which may be met with, or of the obstacles which may be presented by the natural features of

the ground. General rules for proceeding under all the various circumstances which may occur cannot be given, but the following examples will show what may be effected in certain cases, and indicate the character of the operations usually required.

(Fig. 101) represents a common hedge and ditch turned into a

Fig. 101.

breastwork to be defended from the hedge side. If the hedge be thick and planted on a bank as is generally the case, and especially if the ditch be tolerably deep and contain water, the breastwork will be rendered strong at the expense of little labour. A shallow trench should be excavated behind the hedge and the earth thrown up to raise the bank sufficiently to form a rough breastwork some 18 inches thick at the top. Should the hedge be more than 6 feet high, it should be cut to that height, and the branches interwoven with the lower part to strengthen it.

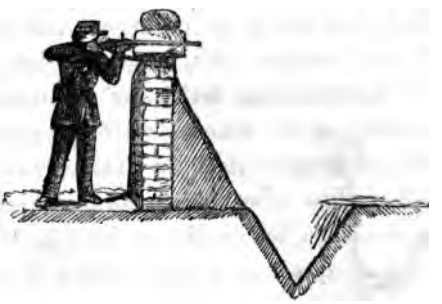
A hedge to be defended from the ditch side (Fig. 102) is a ready-

Fig. 102.

made trench and breastwork, and will become a convenient work by a little scarping of the sides and widening and levelling of the bottom of the ditch, and by the addition if necessary of a banquette.

155. A good nine-inch brick-wall is musket-shot proof. Such a wall 4 feet high will require no alteration, but may be used as a parapet by forming loop-holes with sandbags laid on the top thus:

Fig. 103.



Should there be time, a ditch should be dug in front, and the earth thrown up against the front of the wall to prevent the enemy from using the loop-holes against the defenders.

A wall 15 feet high can be pierced with two tiers of loop-holes, one at 8 feet above the ground, the other at the top of the wall. In rear a scaffolding must be erected of two stages to serve as banquettes. Such an arrangement is shown in the diagram (Fig. 104).

Fig. 104.

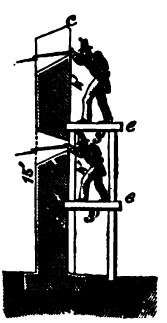


Fig. 105.

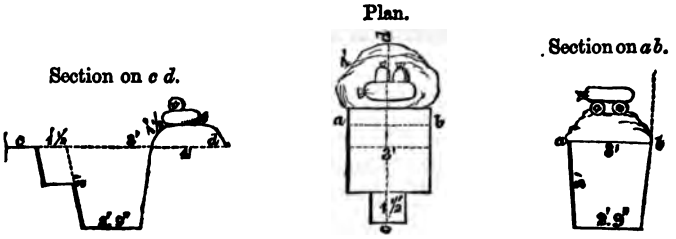
A wall 8 feet high may also be pierced with two tiers of loop-holes as shown in the diagram (Fig. 105). A trench must be dug in this case, to enable the defenders to make use of the lower tier of loop-holes, and a scaffolding erected to serve as a banquette for the upper.

On an emergency, materials of almost any conceivable description, as sacks or casks of earth, of sand, of coal, or even of corn or flour,

bales of cotton, of cloth, packs of wool, mattrasses, trusses of hay, faggots, carts or waggons of stable litter, brick rubbish or paving stones may be formed into parapets capable of defence, while the approach of an enemy may be rendered exceedingly difficult, by a judicious combination of obstacles of which the more common will be hereafter described, but which under urgent circumstances may be extemporized of trees, bushes, posts, waggons, wheels, strong palings, chairs, tables, and miscellaneous articles of furniture, with iron rails, pitchforks and agricultural implements, carefully arranged in the front, and secured by chains or ropes strongly picketed to the ground.

156. Every soldier should be able to form for himself a rifle pit. This can be accomplished by digging a hole in the ground about 3 feet deep and 3 feet square at the top, with a little step to enable him to get in or out with ease. The excavated earth should be thrown up to the front to form a protection. A loop-hole should be made by three sandbags; two placed longitudinally, and one across. A rifle pit of this construction is shown in plan, section, and elevation in the annexed diagram.

FIG. 106.



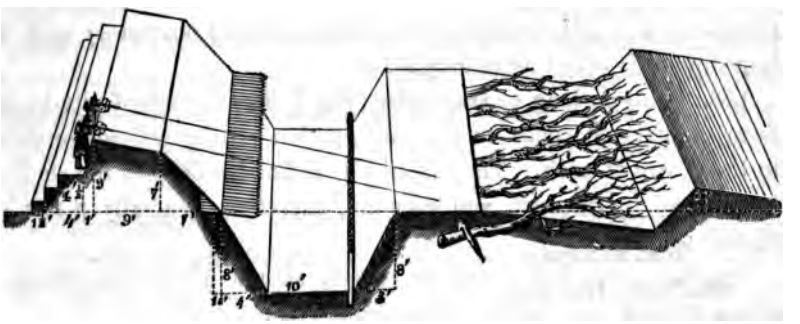
Approach to field works should be rendered difficult by the formation of obstacles of various kinds, so that troops when coming to the assault may be detained under heavy fire as long as possible while they are endeavouring to force or surmount the obstacle.

Contrivances of this nature are very numerous. Those most usually employed are Abattis, Trous-de-loup, Crows'-feet, Chevaux-de-frize, Inundations.

157. Abattis (Fig. 107) are lines of felled trees of a considerable size: their stems strongly bound together and picketed down, while their branches are spread towards the enemy, and interlaced as much as possible, the small branches cut away and the boughs well pointed.

Whenever practicable, abattis should be covered by an advanced glacis to hide it from the view and the fire of the enemy's artillery, and expose the assailant, in forcing it, to the full fire of the parapet in the rear. Well disposed abattis make formidable obstacles, and have always been highly esteemed and much used in ancient and modern warfare.*

FIG. 107.



Abattis is an excellent mode of blocking up a road, and when the branches are well and properly placed and interwoven one within the other, their disentanglement is extremely difficult, and it is an opera-

* At page 360 of the third volume of Col. Napier's History of the War in the Peninsular, in describing the lines of Torres Vedras, it is said: "Across a ravine on the left, a loose stone wall, sixteen feet thick and forty feet high, was raised: and across the valley of Aruda, a double line of abattis was drawn, not composed, as is usual, of the limbs of trees, but of full grown oaks and chestnuts, dug up with all their roots and branches, dragged by main force several hundred yards, and then re-set and crossed so that no human strength could break through. Breast-works, at convenient distances, to defend this line of trees, were cast up, &c."

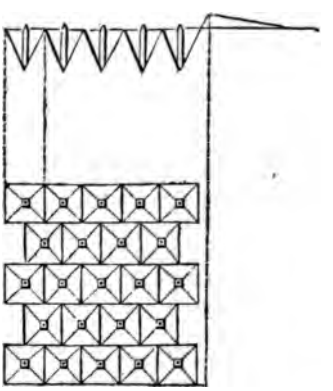
A striking illustration of their value and importance in retarding the advance of troops, was furnished in the Mahratta war of 1817 and 1818, in the case of a division of the British army with a siege train, employed in the capture of the Peishwa's fortress in the Concan; a mountainous district peculiarly difficult for such movements. Forest trees were felled by the enemy, and so laid as to interlock immediately across valleys and ravines in the path of our army: not unfrequently supported by direct and flanking fire from matchlocks and iron rockets. Had these very strong positions been at all adequately defended, they might have cost the advancing army dear to effect a passage, from the impossibility in many cases of moving the heavy artillery and stores by the flanks. And even when these had been turned by light troops, and the position gained with serious loss of life on both sides, the progress of the army was still further delayed until the gigantic abattis could be burnt down, the only practicable way of effecting a passage, thereby giving time to the retreating enemy the better to prepare their adjacent fortresses for a siege.

tion requiring considerable time to form an opening sufficient for the passage of artillery, or even of cavalry. An abattis can easily be made by a few men with half a dozen felling-axes and a cross-cut saw; and if trees of sufficient size are on the spot or near, it is more easily formed and gives a more effective defence than palisades. An abattis should not be planted out of musketry range, for this and all other obstacles are intended to break up the order of the enemy's advance, to impede and to keep him under musketry fire. Heavy trees, with the trunks cut half through, form insurmountable obstacles; such an impediment is called an entanglement.

158. Trous-de-loup, or trap holes (Fig. 108), are rows of pits in the form of inverted cones or pyramids, with a strong palisade or stake in the centre of each. They should be either too deep or too shallow to be used by riflemen, and they are, therefore, generally 8 feet or 2½ feet deep.

Trapholes, whether round or square, should always be arranged chequerwise, to prevent an enemy passing them easily.

Fig. 108.



The earth from them should be formed into a glacis in front, rather than heaped up between them, as, in the latter case, they might be easily filled up again.——Trous-de-loup of even two or three feet deep may be usefully employed, in rendering impassable, shallow wet ditches, inundations, and fords; and like abattis, they may be advantageously placed on the salients of works, on the weak points of lines, or in their intervals. They may thus compel the enemy to attack the strongest parts.

159. Common harrows, picketed to the ground, with the spikes uppermost, form excellent temporary obstacles. Crows' feet (Fig. 109), consisting of four iron spikes arranged at equal angles with each other, so that in any position one spike must be pointing vertically upwards, may be scattered about in front of salients or other weak points, and will render approach difficult, and for cavalry impracticable.

FIG. 109.

160. Roads or breaches, and sometimes even the restricted front of a position, may be barred by chevaux-de-frize, two forms of which are exhibited in the annexed diagrams (Figs. 110, 111). Chevaux-de-

FIG. 110.

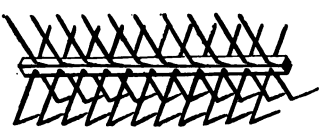


FIG. 111.

frize may be formed of stout square or hexagonal beams, with iron pikes or sword blades, or even stout pointed stakes let into and standing perpendicularly from the faces, or like Fig. 111, of stout palisades, pointed and furnished with legs to support them, with the points towards the enemy.

When used to close a space of any extent, indeed where more than one length is necessary, they should be secured to each other by chains, to prevent their removal by an enemy.

161. Whenever local circumstances permit the ditches to be filled with water to the depth of 5 or 6 feet, this advantage should not be neglected; as not only the defects of dead angles will be greatly remedied, but the enemy will be forced to employ more than ordinary means to approach the work. If a small river or rivulet pass within musket range of the work, the difficulty of access to the latter may be increased by throwing up dikes across the course of the river, thereby spreading an inundation over the adjacent ground. These dikes should be so placed as to be enfiladed or flanked by the fire of the work; and when time and workmen are not wanting, the most exposed amongst them may be covered or supported by a small redan, to prevent the enemy from approaching and draining off the waters of the inundation. Dikes should not be higher than 9 or 10 feet,

because the expenditure of labour and material increase in the same ratio with the areas of the sections of the dikes, and therefore in a greater ratio than the heights of the dikes.. Hence, when several are used, the difference of level between any two adjacent dikes should not exceed 4½ or 5 feet, in order that the most shallow parts between them may not be fordable. Therefore, after fixing the position of the first dike, those of the others will depend upon the natural slope of the bed of the stream, which must be determined by levelling, or ascertained from the neighbouring millers. The summit of the second dike will be placed 4½ or 5 feet below that of the first; that of the third as much below that of the second; and so on with the rest. Hence it follows, that inundations are inapplicable to hilly countries.

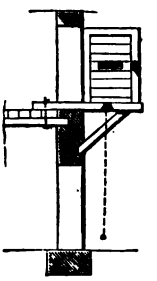
Extensive inundations weaken an assailant by limiting his choice of the fronts to be attacked, and by interrupting his communications. They strengthen the defence by enabling the garrison to concentrate their means on the few fronts liable to attack, and to direct the faces of their works on parts of the inundated land where the enemy cannot establish his enfilading batteries. Inundations are sometimes objected to from the malaria and disease they are liable to generate.

162. In defensive warfare it is frequently necessary to intrench towns and villages, to secure them from the incursions of small parties or to serve as points of support for the movements of troops. If a town or village be commanded on all sides, or even by great elevations on one side, if the houses be of wood and the roofs thatched, so as to be easily set on fire, such a position should be avoided. Neither should a detachment of troops occupy a town or village too extensive for their number, unless a part of the village can be easily and effectually separated from the rest. The number of the detachment should at least equal the number of yards in the exterior line of works by which the village is surrounded.

163. To place a village in a state of defence, the first object will be to complete a continuous line of defensive works, by which it may be entirely surrounded. To this end advantage is taken of all buildings, fences, and walls, near the exterior edge. The buildings, when substantial, may serve as bastions to flank the connecting lines of works, and when due preparations have been made will become strong positions. The walls and hedges must be strengthened by banks of earth, and will form curtains connecting the stronger portions. All

openings remaining must be closed by parapets, strengthened by ditches, abattis, palisading, and such obstacles as the locality may present, and the streets must be barricaded at intervals. Barricades may be constructed of materials of almost any kind—of earth, of timber, of paving stones, of waggons of stable litter (the wheels should be taken off). In buildings occupied for defence the doors and windows should be blocked up with sand-bags, supported by frames of wood, and the glass must be removed from the windows. Should there be no projecting wings or porches, it will be necessary to obtain a flanking fire by the construction of balconies projecting from the windows, and furnished with loopholes in the sides and bottom, so that a flanking fire can be brought to bear on the ground at the foot of the wall. This arrangement is shown in the diagram (Fig. 112). The beams supporting the gallery or balcony are bolted to the flooring within; the balcony is surrounded with good oak boarding of 4″ or 5″ thick.

FIG. 112.



164. That the communications of the defenders may be free, all interior hedges and walls which can in any way impede their movements must be levelled, so that they may be able to bring support rapidly to any point pressed by an enemy.

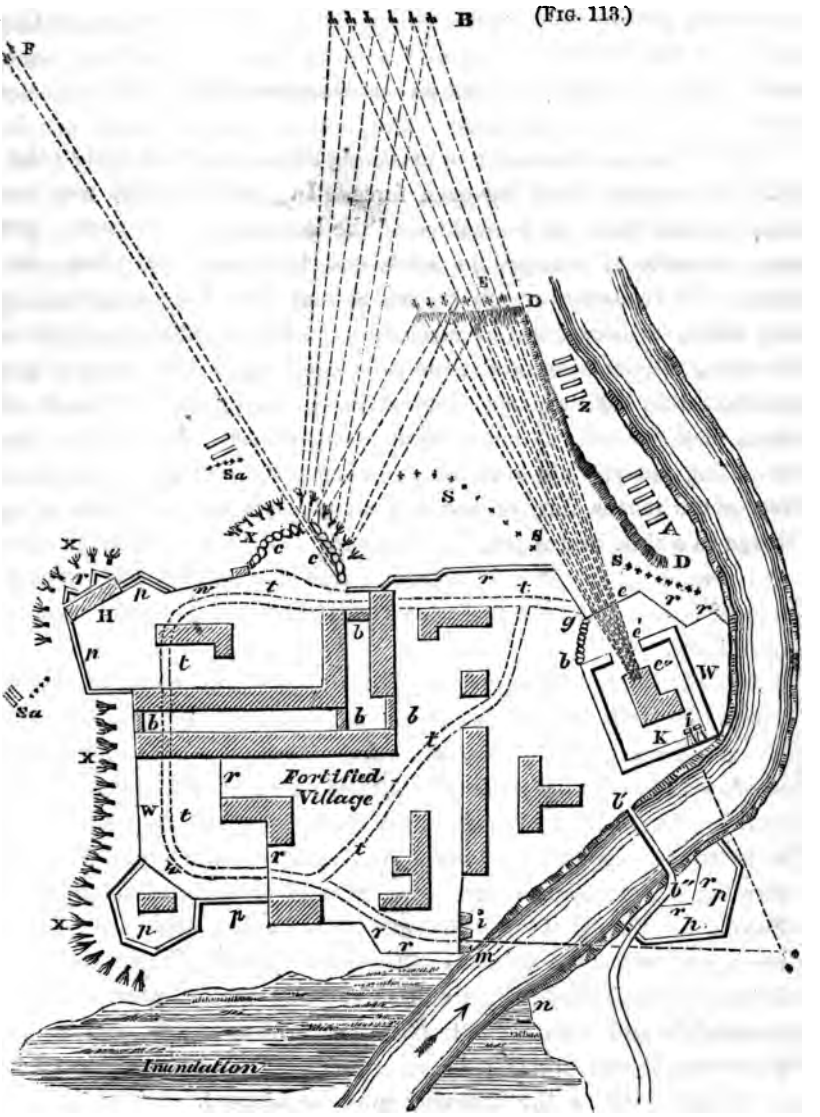
Those hedges which it may be desirable to retain must be strengthened in the manner already pointed out in Article 154.

165. The strength of the position may (when circumstances admit) be greatly increased by the formation of an interior keep, whither the defenders may retire and obtain favourable terms of capitulation should they be unable to withstand the assaults of their assailants. A substantial building within the town, as an old castle or jail, may be converted into a keep by blocking up unnecessary openings; by covering entrances or any unflanked portions of the walls with tambours; by loopholing the walls and surrounding them if possible with a ditch, palisade, and abattis. In the absence of a building of this nature, it will be desirable to construct a redoubt, of as strong a character as time will allow. If the village be of considerable extent, and a position can be found which cannot be commanded from the neighbouring buildings, the redoubt may be of earth, as in an ordinary Field-work.

166. While the actual defences of the village are thus being

prepared, parties will be occupied on the ground without, in creating obstacles and entanglements in the immediate vicinity of the place, and in removing and levelling all obstructions between such obstacles and the limits of rifle range. The greatest obstacle which can be presented to an attacking force will, in future, be a long level tract, fully commanded by a sweeping fire. It is, in fact, difficult to see how an assaulting body could pass over such a tract of 1,000 or 800 yards in extent, to attack a work in day-light without being annihilated. To remove every object, whether tree or bush, rising ground, dry ditch, or hedge, which could afford cover or concealment to a rifleman, will be an object of primary importance in executing the arrangements for defence. Ditches full of water, or which can be filled, may generally be left, as they impede, and cannot assist the assaulting party. The annexed diagram (Fig. 113) gives an illustration of the means, already described, usually applicable for placing a village in a state of defence.

(FIG. 113.)



DEFENCE OF A FORTIFIED VILLAGE.

w, loop-holed walls; P, parapets and ditches; *c*, ditto of casks; *x*, abattis; *r*, stockades; *b*, barriers; *t t*, free communication, road or passage; H, fortified house; K, keep.

ATTACK OF THIS FORTIFIED VILLAGE.

D D, flying sap-parallel or trench of cover; B, open field battery, first opened at about 350 yards' distance; E, ditto, advanced to breach; F, one 9-pounder and one 24-pounder nowitzer, to enfilade flanking defences; *e e e''*, breaches; A, storming party; Z, supporting ditto; *s s s*, firing party and skirmishers; S *a*, false attacks, to divert the attention of the garrison at the moment of the real assault.

On the attack of Field-works.

167. There are two modes of attacking fortified posts or field-works: 1st, by surprise; 2nd, by open force. In both cases the assailant must have a thorough knowledge of the localities and defences: this can generally be obtained by spies, deserters, maps, and plans; also from the peasantry, especially such as may have been employed by the defenders as workmen or mechanics. All such information should be taken with caution, and none fully relied upon that has not been confirmed by the personal observation of intelligent officers, or, in small detachments, by non-commissioned officers. A good telescope is an indispensable aid in obtaining information.——Should an officer, charged with the duty of carrying an enemy's fortified post, be induced to attack it at night, his arrangements should be of the plainest and simplest character; for anything that is otherwise, is almost certain of failure from the confusion that darkness brings into all such operations.

168. An attack by surprise. The strongest and most formidable works have been carried by surprise and boldness, through the negligence and misconduct of the defenders. Attempts of this kind will be regulated more by the latter consideration than by the strength of the works. First. If the enemy has neglected to place piquets, videttes, or sentinels, outside of his works, and omitted other precautions, indicating a state of carelessness, or want of professional intelligence. Secondly. Should it be ascertained that he has neglected interior arrangements for the defence of the works. Third. Should his troops be raw, undisciplined, or his officers slovenly, then a surprise may be successful; and with good troops, good arrangements, and a bold execution, it will probably be so. To carry this service into effect, some such plan as the following must be adopted. 1. Be perfectly secret in your intentions until the moment it becomes necessary to communicate to others what they have to do. 2. Determine whether your troops are to destroy or to hold the work; give orders and make clear arrangements accordingly. 3. Divide your party properly; some for the real attacks, some for false attacks, to be turned into real attacks if the opportunity offers. 4. Select a party of picked men, and provide them with axes, sledge-hammers, crow-bars, bags

of powder,* of 20, 30, or 50 pounds each, with fuses prepared, and with gimlets to attach them to barriers, stockades, covered caponnieres, &c., or to lay them down against such obstacles. Each party should know thoroughly what is its duty and object; and there should be a conventional sign or badge.

169. Perhaps the best time for assaulting a work is early in the morning, or just before the moon rises; as the previous darkness covers all the preparatory arrangements. If the assault be made at night, it has been recommended to intrust a few steady men with port-fires, to light them in the event of the assaulting party having to penetrate dark passages. Cold rainy nights are favourable for such operations, as sentinels are apt to seek shelter and to become sleepy; and the noise of the wind and rain also prevents the advance of the assailant being heard.

170. In all assaults, whether by surprise or by open force, it is proper to divide the troops into—

1st. Storming parties.

2nd. Supports.

3rd. Firing parties.

The last will seek cover as near the work as possible; and, on the appointed signal for the storming parties to advance, this firing party will spread itself out in extended order, to keep down the fire of the defenders; if possible, preventing any man showing his head above the parapet, and firing steadily into the embrasures, to slacken the service of the guns. If the attack be by surprise, the firing party may be small; and as this attempt would be made only in the event of the enemy being quite unprepared, no firing or noise of any kind should take place until the assailants are in the work and upon the enemy. The assaulting parties must be followed by the supports, as soon as it is supposed that they have overcome the first obstacle. The supports should be ready at hand, not too soon in following; but above all not too late.

171. Should escalade be necessary (as it almost always is), as many ladders should be prepared as can possibly be carried and used by the storming parties. When it is considered how slow a process it is

* These bags should be waterproof. A failure occurred in the North of India, in consequence of continued rain and snow having made the powder so damp, that a bag attached to the gate would not explode.

to bring up ladders to the counterscarp, in order to descend by them into the ditch, then to cross the ditch and to rear the ladders against the escarp, and to mount them, it is evident that success will, in a great measure, depend upon the number of men that can mount at the same moment; in other words, upon the number of ladders. A ladder beyond a certain length becomes unwieldy, and the rearing of it difficult. The distance from the foot of the ladders to the wall should be at least equal to one-fourth of their height. If the distance be greater, the ladders will be easily broken under the weight of the men mounting them; if much less, they will be so erect that the soldiers, as they ascend, must be continually in danger of falling headlong down. The scaling ladders, introduced by Sir Charles Pasley, used at the Engineer Depôt of Instruction at Chatham, are in pieces of 12′ 8″ and 7′ 6″ in length, fitting into each other with strong double iron sockets, and tied by stout ropes. These can be arranged for any length, and quickly adjusted. Ladders made of long spars are awkward to carry; especially if there be narrow sharp turnings in approaching the point of escalade: nor can long sound spars be always procured. It is desirable that ladders should be made of light tough wood: teak wood is too heavy. If a guy-rope be attached to each side of the ladder, they greatly assist in adjusting and fixing it against the wall: the men told off for the guy-ropes should stand close to the wall, within the slope of the ladder: these guy-ropes should be fixed at 5 or 6 feet below the top of the ladder, to prevent their being cut by the enemy on the wall. The total lengths of the ladders should exceed the height to be escaladed by 3 or 4 feet, in order that the men may step easily off the ladders on to the parapet or wall. Many failures have occurred from ladders being too short. It is desirable to have a pair of stout lifting bars, 3 or 4 feet long, with hooks, for each ladder. When an escalade is to take place, be sure to practise the men intended for the service thoroughly in carrying, in fixing, in ascending, and descending the ladders; descending, for going down a counterscarp; ascending, for getting up an escarp. Always use as many ladders as possible. If there be a counterscarp to descend, leave half the ladders there, while the other half are used against the escarp, that no time may be lost. Ascend the ladders together, on as large a front as possible. When an escalade is opposed by an enemy, take care that a good firing party covers the escalade, with especial directions to fire upon any work that may flank the ladders. Avoid

night attacks, except under peculiar circumstances: the example of gallant men is lost at night, whilst the timidity of some becomes infectious. Make all your arrangements under the cover of darkness, and assault as the day breaks. The bamboo, which grows so abundantly in India, makes excellent scaling ladders. Those of the largest size, being 3 or 4 inches in diameter, sufficient for lofty escarps, are not always procurable in the required lengths; but two or more such bamboos may be bound together securely, with the step bars not let into holes, but lashed on, either single or double, at intervals of 9 inches apart. The hollow bamboos being very light and portable, thus strengthened, make very good ladders, without being too heavy to be carried and raised. It is doubtful whether any ladders could be manageable of a length suitable for an escarp of 35 feet, of a strength capable of bearing the weight of a number of men crowding up, as is usual with storming parties: hence a revetment of 35 feet has been generally considered too high for escalade. Cases, however, doubtless, may occur, as they have in India, in which it may be necessary to carry such works by assault; especially hill forts, in which the escarp is considerable, in such cases the ladders should be strengthened to the utmost, provided their portability be not sacrificed, by every additional support in the way of prop-stays and guy-ropes, &c.

172. Regular attack of field-works by open force. It is highly imprudent to attempt to carry well-flanked and formidable field-works, defended by good troops, by storm; for, until the flanking defences are greatly injured, and good openings made by artillery, for the assailants to gain an entrance, any attempt to force such posts must be attended with an unwarrantable sacrifice of life. The principles of a regular attack must, in their case, be partially followed.

173. The principle upon which all well-flanked formidable works, defended by good troops, should be attacked, is, the construction of a succession of good trenches, to contain strong guards to meet sorties, and to reply to the musketry fire of the defences—the construction of batteries of artillery, to enfilade and subdue the defensive artillery from a distance, to dismantle the parapets by a fire of shot and shell, and to sweep their terre-pleins—the formation of breaching batteries, to make openings fit to assault—and, finally, the destruction of the counterscarp by mines, in order to join the rubbish upon the opposite sides of the ditches, as a path for the assaulting parties.——In most cases, these operations may be greatly abridged, although the prin-

ciple must be adhered to. In nearly all fortified villages or posts, some of the walls or defensive stockades, &c., can be seen from a distance down to their very bottom, and therefore breaches can be made without advancing the batteries within the musketry range of the defences. This, when it can be done, is very desirable, as gunners suffer greatly from a good steady musketry fire into the embrasures. Nor would it be necessary, in most cases, to carry forward the trenches or saps close to the walls, as many walls and barriers are without ditches in front, and are therefore open and seen; in which cases the breaches can be effected at from 400 to 800 yards, and can be reached by the storming parties advancing over the intervening space between them and the trenches. This space, should not be too great, and the defensive parapets must be dismantled, so that the assaulting columns may not be exposed to a heavy fire in advancing to carry the work. Their success depends on the breaches being quite accessible, their reaching them in perfect unbroken order, and their being well led on by able officers.

CHAPTER VII.

FIELD WORKS.

174. The operations of an army in the field, whether acting on the offensive or on the defensive, may be frequently greatly assisted by, and in fact will generally require the aid of, works of fortification of a simple character. By such works, rapidly thrown up, battle-fields judiciously chosen, may be greatly strengthened, communications with the base of operations be strictly preserved, and the bridges protected from destruction by an enemy. Or when on the defensive, an extensive position may often be rendered unassailable, and the army entrenched within it secure from the assaults of a superior force, may recruit its strength and await a favourable opportunity for recommencing its operations.

The works which are constructed for any of these purposes are called Field Works, and differ from permanent fortifications only in detail, not in general principles. In field works less permanence is necessary; they are constructed for temporary purposes, and are seldom required to last beyond the limits of a campaign, while in some cases a few weeks, days, or even hours, may terminate the objects of their being.

They are, therefore, in general less extensive, less massive, less formidable, less durable, with smaller ditches and lower reliefs, and though they ought to be as carefully planned, they will seldom be as carefully finished. The use of masonry, moreover, is prohibited by the nature of the case, whence the sides of the ditches, except in very stiff

soils, or in chalk, will have a considerable slope, and the ditches will present a slighter obstacle to a sudden assault. The general principles remain the same whether applied to permanent or to field works. The same attention must be paid to relief and command, to the flanking of the ditches, and the absence of dead ground in front, to the formation of obstacles in the path of an assailant, to the protection of the interior from enfilade and ricochet fire, and to the construction of retrenchments within.

The works which may be necessary or desirable in any particular case, will depend entirely upon the circumstances of that case. They may have any extent, from a simple redan, or a battery, to a line or several lines of works, some of considerable magnitude, extending over a position of ten or twenty miles. It will only be possible here to give a brief description of the works usually adopted for these purposes, and a general idea of the principles which govern their special application.

175. Field works, then, are usually arranged in three classes:—

First Class, consisting of works open at the gorge—

Redan	Double Redan
Redan with Flanks	Tenaille Head
Lunette	Bastion Head

Second Class, consisting of works enclosed all round—

Redoubt
Bastion Fort

Third Class, consisting of lines both continuous or at intervals—

Lines of Redans	Lines of Bastions
Lines of Tenailles	Lines at Intervals
Indented Lines à la Crémaillere	

176. A Redan is a work of the simplest kind. It consists of two faces of parapet and ditch, forming a salient angle. Redans serve to cover bridges, causeways, avenues, &c., and being quite open at the gorge, are only suited for positions in which their extremities rest on rivers or other obstacles, so that they cannot be turned, or else when protected by the full sweeping fire of works in their rear.

Redans in front of other works are generally mere covers for an advanced post; for example, if a strong redoubt occcupies the commanding summit of a hill, its elevation and position usually prevent

the deep hollows and approaches by the valleys being fully seen from its faces. Redans may then be advantageously constructed on the lower knolls, or under features of the hill, to command all the hollows, which cannot always be reached by the fire of the main redoubt.

FIG. 114.
Redan.

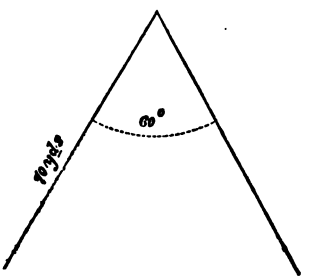
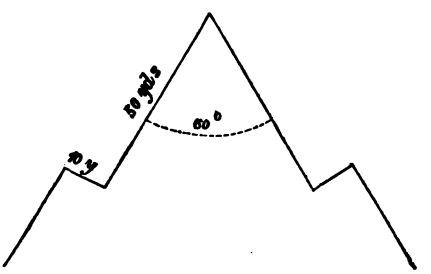


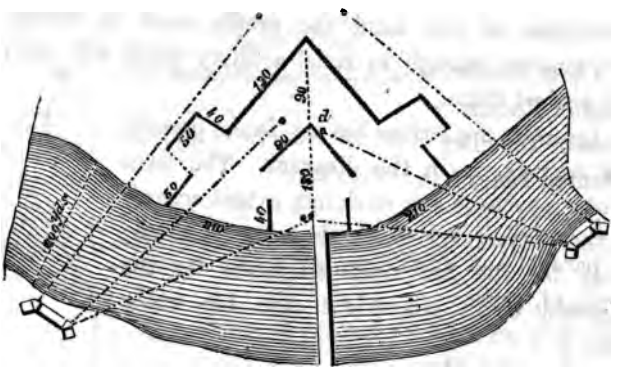
FIG. 115.
Redan with flanks.



Scale, 45 yards to an inch.

177. Redans with Flanks Redans are frequently provided with flanks. These flanks should be 10 or 20 yards long, perpendicular to the faces, and distant from 40 to 60 yards from the flanked angle, so that their fire may flank the capital. As the ditches of redans are not flanked, they should be brought to an angle at the bottom, and the defenders should be provided with hand grenades to throw over the parapet for the defence of the ditch.

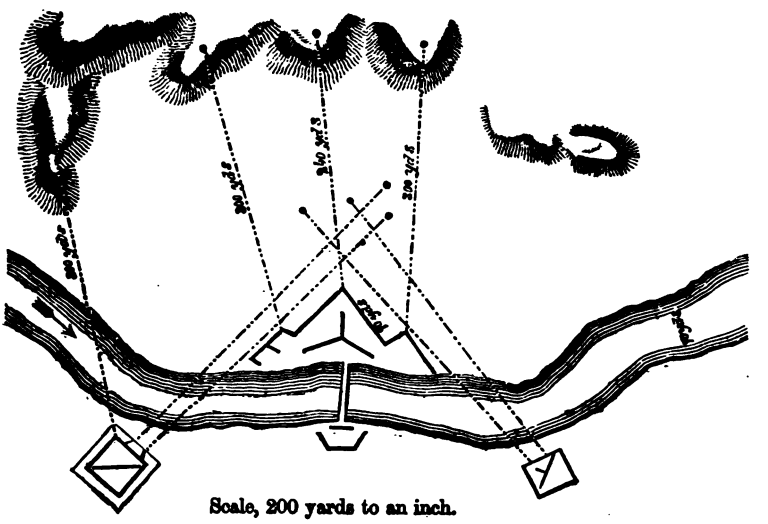
FIG. 116.



Redans with flanks supported by batteries and redoubts are not unfrequently applied for the defence of bridges. Instances of this arrangement are shown in the annexed diagrams of bridge-heads. Figs. 116, 117.

Fig. 117 exhibits a bridge-head, composed of a redan with flanks, flanked by two redoubts on the opposite bank of the river. These works are supposed to be in the neighbourhood of hills, from which it is necessary that they should be defiladed. This is effected by traverses to cover the bridge, and by a traverse across the centre of each redoubt.

Fig. 117.

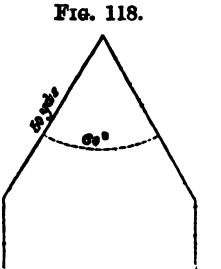


Scale, 200 yards to an inch.

In positions of this kind the profile must be strong, and the parapets massive enough to resist artillery which will not fail to be brought against them.

178. Lunettes are redans having flanks parallel to their capitals, as in the diagram. The faces and flanks may have any moderate extent according to the purpose for which they are intended; 50 yards for the face, and 25 yards for the flank, would be a convenient size for many positions.

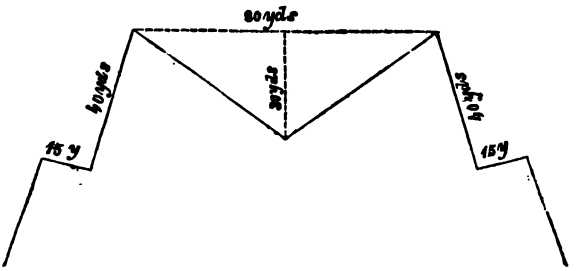
Fig. 118.



179. Double Redan. Two redans joined together form a double redan, or tete a queue d'hyronde. The re-entering angle should be as nearly a right angle as possible. The front about 80 yards long. The salient angles never less than 60°, and the flanks about 20 yards

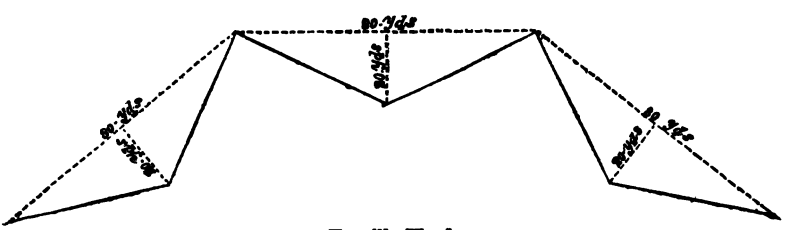
in length. Should the ground to be defended require more important or extensive works, the bastion trace would probably be adopted.

FIG. 119.



180. Lines of rampart and parapet, forming alternate salient and re-entering angles, constitute the Tenaille Tracing. The Tenaille Head is formed by two or three fronts of this trace, each of 80 to 100 yards in length, with or without wings, resting on a river or on works in the rear.

FIG. 120.

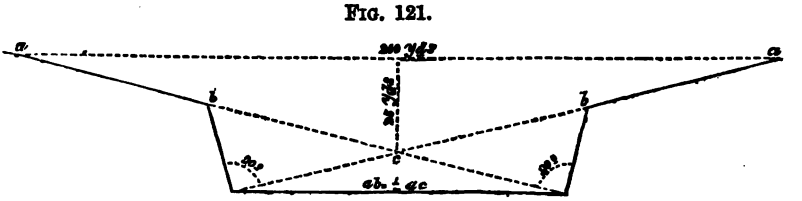


Tenaille Head.

Scale, 50 yards to an inch.

181. A Bastion Head is composed by one, two, or several bastion

FIG. 121.

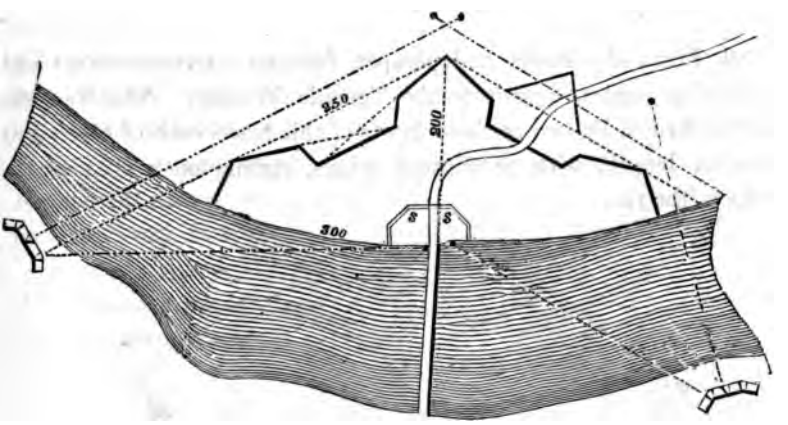


Bastion Front.

fronts, forming obtuse angles with each other. Such a front is shown in the annexed diagram (Fig. 121).

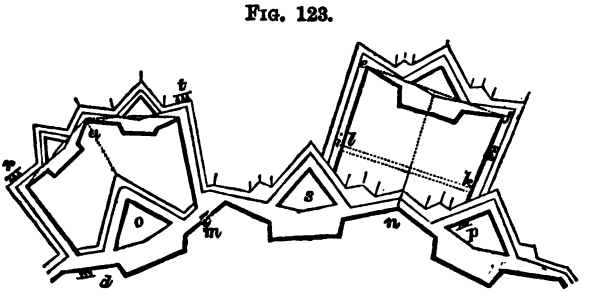
Bastion heads are usually applied to fortify important bridges on the lines of communication of an army in the field (Fig. 122), and they must then be works of very considerable extent. In such a case the profile must be strong, the ditch as wide and as deep as possible, and when circumstances admit, filled with water. An interior redoubt or stockade at the head of the bridge will also be necessary. It may save the bridge, should the rampart be carried by a sudden assault. Strong batteries, armed with heavy guns, should be erected on the opposite side of the river, to flank all the ground before the fronts.

Fig. 122.



Bastion heads are also frequently thrown out in advance of other works, to which they are connected by lines of rampart and parapet called wings. In these cases they take the name of Horn Works and Crown Works; the former when one front, the latter when two fronts

Fig. 123.



are employed. Examples of a Horn Work and of a Crown Work are given in the annexed diagram (Fig. 123).

182. Redoubts are works enclosed on all sides, of a square, polygonal, or circular figure. The latter form is rarely used, being unsuitable to ground in general, and from the impossibility of giving any flanking defence to the ditch.

Redoubts on level ground are generally square or pentagonal. On a hill or rising ground their outline will in most cases follow the outline of the summit of the hill. Their dimensions should be proportioned to the number of men they are to contain. One file, that is, two men, are required for the defence of every lineal yard of parapet; the number of yards in the crest line of any redoubt should not, therefore, exceed half the number of men to be contained in it. Again, it is considered that every man in an enclosed work requires 10 square feet of the interior space, whence the interior space of a redoubt, clear of the banquette, must not contain less than ten times as many square feet as the number of men to be contained in it.

183. From these considerations we deduce two rules:—

1st. To find the least number of men sufficient to man the parapet of an enclosed work, multiply the number of yards in the crest line by two.

2nd. To find the greatest number of men that an enclosed work can contain, find the area, clear of the banquette, in square feet, and divide this number by 10.

When the redoubt contains guns, 324 square feet must be allowed for each gun, and this quantity, multiplied by the number of guns, must be subtracted from the whole interior space.

The remaining number of square feet divided by 10 will give the number of men which the redoubt can hold.

184. To find the side of that square redoubt which can just contain enough men to man the parapet.

Let N be the greatest number of men the redoubt can hold.

Let n be the least number of men sufficient to man the parapet.

Let x be the length of the crest line of one side in feet. The banquette will take up a space of 12 feet all round, therefore the length of the side of the interior space, clear of the banquette, will be equal to $x - 24$ feet. Therefore

$$N = \frac{(x-24)^2}{10} = \frac{x^2 - 48x + 576.}{10}$$

Also—

$$n = \frac{4x \times 2}{3} = \frac{8x}{3}$$

But by the conditions of the problem $N = n$.

$$\text{Therefore} \quad \frac{8x}{3} = \frac{x^2 - 48x + 576}{10}$$

$$\text{Or} - \quad x^2 - \frac{224x}{3} = -576$$

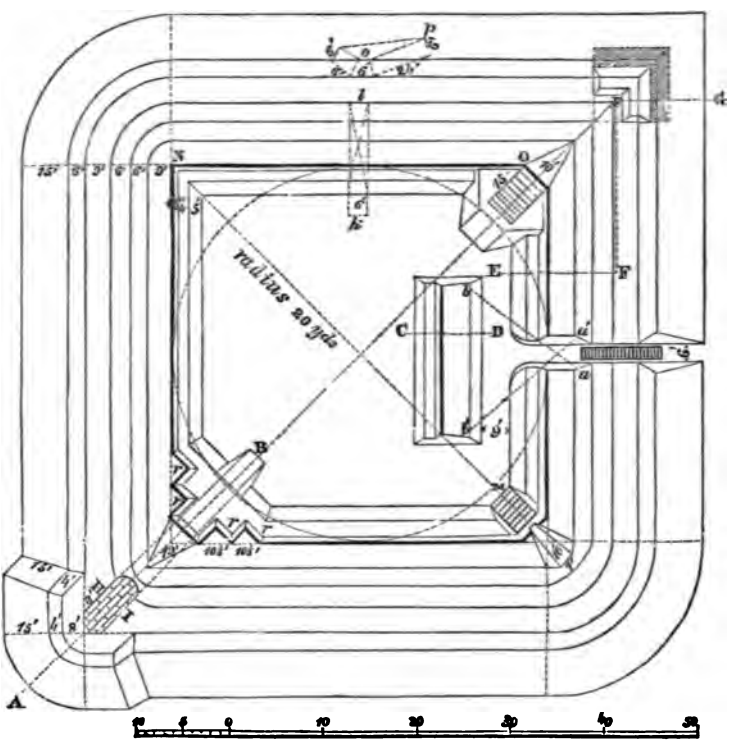
The solution of this quadratic gives us for one of the value of x

$$x = 46.5 \text{ nearly.}$$

Hence the side of a square redoubt should under no circumstances be less than 50 feet.

FIG. 124.

Side of the Square along the Crest, 40 yards.



Scale of yards for Fig. 124, and of feet for Figs. 125, 126, 127.

185. The great objections to small enclosed works are, 1st., the liability of their faces to be enfiladed from without; 2nd, the difficulty

of providing an effective flanking defence for their ditches; 3rd, the weakness of their salient angles, the ground in front of them being undefended by a direct fire.

186. In the annexed diagram (Fig. 124), is shown a square redoubt, having a side of 40 yards, and capable of holding four pieces of artillery and one hundred and twenty men.

A description is given somewhat in detail, of the dimensions of the parapet and ditch, of the provisions for flanking defence, and of the general arrangements of this redoubt, as an example of the usual requirements of works of this nature.

In this redoubt, one angle, M, is furnished with an embrasure and platform for a gun; another, O, with a barbette, a favourite plan of furnishing a fire on an unprotected salient, but which the recent improvements in small arms have rendered impracticable.

At the third angle, the crest line is broken into short faces alternately parallel and perpendicular to the capital, so as to furnish a musketry fire over the undefended ground in front of the salient.

The ditches of these redoubts are usually flanked, either by covered caponnieres, or by reverse galleries, placed at the angles. An instance of each construction is shown in the plan (Fig. 124), and on a larger scale in the sections (Figs. 125, 126, 127).

FIG. 125.
Section on A B.

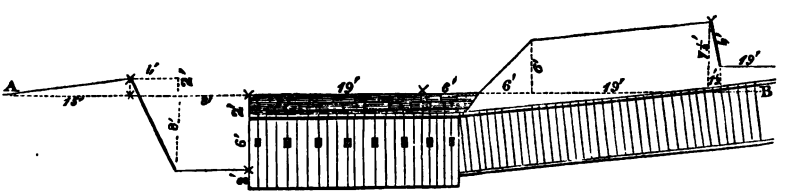
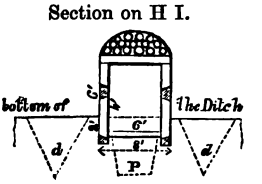


Fig. 125 shows a longitudinal, and Fig. 126 a transverse, section of the covered caponniere. It is formed by two rows, some 8 or 10 feet apart, of trunks of trees, or stout beams, not less than a foot thick, planted vertically in the ground, touching each other and pierced with loopholes at intervals of 3 feet. The roof is a timber framework, supporting several layers of fascines, which are covered over with a foot or two of earth.

FIG. 126.
Section on H I.



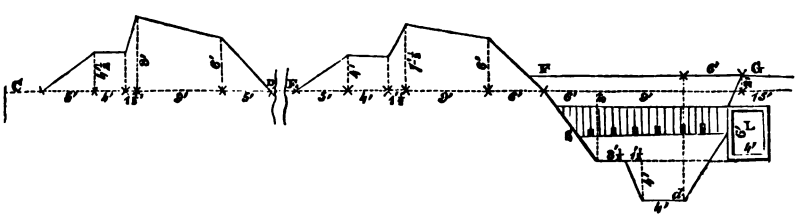
To prevent an enemy from making use of the loopholes against the defenders, a drop ditch should surround the caponniere, or its floor should be sunk two feet below, and the loopholes be pierced two feet only above, the bottom of the ditch. In this case it will require careful draining.

The caponniere must not reach across the ditch, or the assailants will use it as a bridge. The ditch surrounding its end should be 12 feet wide at the top. A gallery supported by timber framing, or by mining cases, passing under the rampart, forms the communication between the interior of the caponniere and the interior of the redoubt.

The reverse or counterscarp gallery is a chamber excavated under the counterscarp a short distance on each side of the angle. The

Fig. 127.

Section on E F G.



front of this chamber is closed by a musket proof stockade of beams not less than one foot thick, pierced with loopholes at intervals of 3 feet, and further protected by a drop ditch in front. Communication is carried on by a gallery under the rampart into the ditch, and by a door from the ditch; or a gallery passing under the rampart and ditch opens directly into the interior of the chamber. This is a more secure, but more difficult, construction, and applicable only to particularly dry situations.

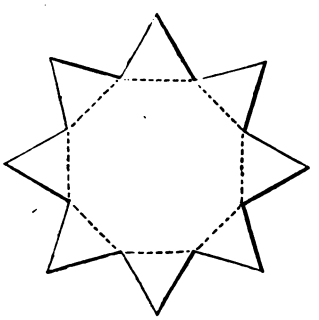
187. In tracing redoubts and all enclosed field works, care must be taken to direct as much as possible their faces upon inaccessible ground, so as to reduce to a minimum the effects of an enemy's enfilade, while approach on the salients must be rendered difficult by abattis, trous de loups, and obstacles of all available descriptions.

It will henceforward be very difficult to guard the interior of enclosed works from the effects of distant musketry. Well trained troops from a distance of 900 yards could throw with certainty every shot into the

interior of even a small redoubt; while the angle at which they fall, some 15° to 20°, would enable them to sweep the whole interior, and search into every part. It seems a question how far such a work could be protected by traverses or other devices from the effects of such a deadly plunging fire, or whether it would be tenable at all.

188. Starforts are enclosed works of an outline shown in the diagram. They were proposed to remedy the defects of an absence of flanking defence for the salient angles of polygonal redoubts. In consequence of the great exterior slopes necessarily given to field profiles, the faces are very short and furnish a feeble fire, while the flanking defence is nearly worthless. Jomini says, "Starforts are the very worst description of fortification, they cannot have flanks, and the re-entering angles take so much from the interior space, that it is impossible to place troops and artillery in them sufficient for their defence. They are especially liable to be enfiladed from one end to the other, which precludes the possibility of a long defence."

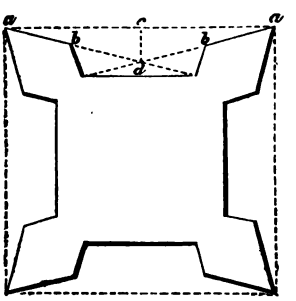
Fig. 128.



Star Fort.

189. Bastioned forts (Fig. 129) are constructed only in cases of im-

Fig. 129.



Bastion Fort.
$a\,a = 140$ yards.
$c\,d = 17\frac{1}{2}$ „
$a\,b = \frac{1}{4}\,a\,d$

portance, where it is wished to present every obstacle to an enemy, and to hinder him from getting possession of the ground upon which they are placed.

Such works should be as formidable as possible. In small works of this nature it is impossible to obtain good flanking defences for the ditches; but in great forts, which generally form the key of a position, the interior space sacrificed by breaking the exterior sides into bastion fronts is more than compensated by the flanking defence thus obtained for the ditch. All the accessories, such as fougasses, abattis, trous de loups should be applied in the situations most favourable for them, and above all casemated, or at least splinter proof cover must be provided on all the faces of which the prolongations fall on the enemy's ground, to secure the defenders from the speedy annihilation which must otherwise infallibly result from the plunging enfilade of the enemy's rifles from a distance of 900 or 1,000 yards.

Bastioned Forts are suitable for many situations, as they can be of almost any magnitude. The length of the exterior side may vary from 100 yards to the length of a full sized front, or 400 yards or thereabouts, as in the forts proposed for the new fortifications at Antwerp.

190. A Blockhouse is a species of enclosed work peculiarly adapted to woody countries, because the materials for their construction are found upon the spot; and as these countries are often mountainous, the enemy cannot, without much difficulty, transport his cannon with him. There is, besides, in such countries, difficulty in finding a site whereon to construct a work of the ordinary uncovered kind, which may not be seen into and commanded by some neighbouring height. The plan of a blockhouse is usually that of a rectangle, eighteen or

FIG. 130.

A Blockhouse or Stockaded Redoubt.

twenty-four feet wide in the inside; but when it is possible to give it greater dimensions, its plan is that of a cross, so that its fires flank

one another mutually. The profile of the blockhouse will vary according as it may be liable to an attack of infantry merely, or of infantry with artillery. In the former case, its sides may consist simply of rows of contiguous trunks with loop-holes made in them three feet asunder. In order that the enemy may not be able to set fire to the work, he must be kept off from it by a ditch, the earth of which is piled up against the work as high as the loop-holes, and is moreover employed to cover the roof, and form also a small glacis round the work.

A blockhouse of this nature intended to resist field artillery must have its walls constructed of a double row of contiguous trunks of trees or piles; the interval between them being filled with well-rammed earth as high up as the loop-holes, the whole composing a wall three feet thick. This work being of a more important nature than the preceding one, its width inside should be twenty-four feet, and the tie-beams, owing to their length, must be composed of two pieces scarfed in the middle, and moreover supported by strong stanchions resting on a ground sill. These blockhouses may become temporary barracks; the cots will serve as banquettes for firing through the loop-holes.

LINES.

191. Continuous lines of rampart parapet and ditch are sometimes used to connect important redoubts, or to cover the front of a position, and they may have, according to circumstances, any of the tracings described in Chapter II. To cover any considerable extent of country with continuous lines is generally considered injudicious, but must not be altogether condemned, as in particular cases, especially on ground unfavourable for manœuvring, it may be an advantageous construction.

Continuous lines require a great expenditure of labour in their construction, and a large force is necessary for their defence: if forced at one point, the whole is lost, and they interfere greatly with the offensive movements of the troops they cover.

192. When circumstances oblige any considerable extent of country to be defended, lines at intervals are more generally adopted.

Lines at intervals are a series of detached works arranged in two or more rows, mutually supporting each other, and each capable of enduring an independent attack.

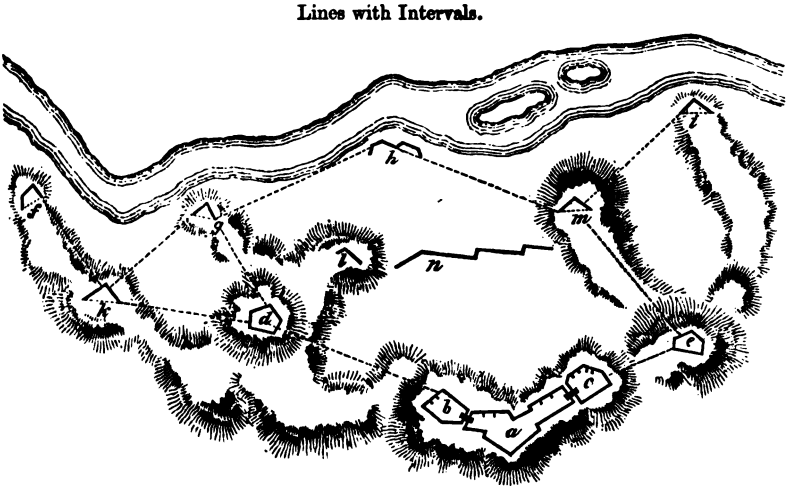
In lines at intervals the most advanced positions are usually occupied by simple works open at the gorge as Redans and Lunettes, within range of each other, that is, not more than 600 or 700 yards apart. These works being open at the gorge, can be fully commanded by the works in rear, which can bring a fire upon every point within them; if taken by an enemy, they cannot, therefore, be held by him until the latter works are also subdued.

The second line of works are generally a series of redoubts, adapted in shape to the features of the ground, 400 or 500 yards behind the salient works, covering their intervals, and protecting their faces and ditches by a powerful flanking fire. If necessary, a third line of works on similar principles may be added.

The works in the second line, *i. e.* the redoubts, must be made as strong in rear as in front, or an enemy would not fail to attempt to carry them by an attack on the rear, and the faces of all the works should, as far as possible, be directed on ground which the enemy cannot occupy, so as to be protected from his enfilade fire.

193. The annexed diagram (Fig. 131) exhibits a tract of ground defended by lines at intervals, and will convey an idea of the general arrangement of works of this nature.

Fig. 131.
Lines with Intervals.



In the construction of these and all other field-works, the following maxims must be strictly observed.

1st. That the works to be flanked, are never to be beyond the

range of the weapons of the works flanking them, that is, never out of the effective range of musketry.

2nd. That the angles of defence should be about right angles.

3rd. That the salient angles of works should be as obtuse as circumstances will permit.

4th. That, although ditches cannot always be as fully flanked, as in permanent fortification, yet that partial flanking must be carried as far as possible.

5th. That in the construction of field-works, reference should not only be had to the direct and immediate obstacles that the work itself presents to the enemy, and the positive effects of fire on the approaches to it; but likewise the relative value of the work must be considered, as to the support it can give to, or receive from, other works.

6th. That the outline of a field-work should be proportioned to the number of men intended to defend it.

7th. The ground over which an enemy must pass to the attack should, if possible, be seen both in front and flank.

CHAPTER VIII.

DEFILADING.—MINING.

194. A hill or rising-ground in the neighbourhood of a work, enables an enemy from its summit to plunge his fire over the crest of the parapet, on to the ground, at a little distance in its rear. Thus the whole extent of the ground, with the exception of a narrow belt immediately behind the parapet, is exposed to the view and fire of the enemy on the top of the hill, and, except under very peculiar circumstances, the work would be useless.

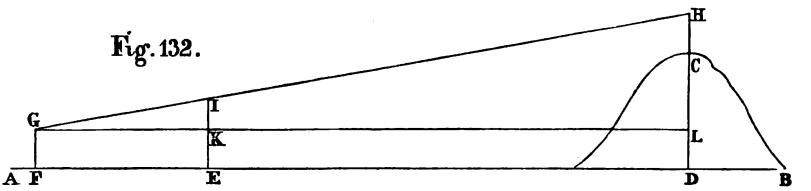
To render a work in such a position secure, some arrangement of the defensive masses, differing from that which would be necessary on a plain, to parry the effects of the commanding ground is required. The proper arrangement of the works for this purpose is called defilading.

195. The simplest case which can occur is when a single line of parapet is required to afford cover to a certain distance in its rear, from the fire from a single hill in its front. This would be effected by adding to the height of the parapet. The requisite height would be thus found. (Fig. 132.)

A B is the plane of site; C the top of a hill; E the position of a parapet; E F the space in rear of the parapet to be protected by it. Then the track of the shot from the parapet at H grazing the crest of the parapet at E, in order to protect a man standing at F, must clear the ground at the point F by 7 feet. Draw F G perpen-

dicular to A B; produce D C to H, making C H equal to 7 feet; join G H, then H G is the track of the shot. Draw E I perpendicular to A B, meeting H G in I; then E I is the height of the parapet required at E.

FIG. 132.



To find E I

Draw G K L parallel to A B,

From similar triangles I K G, H L G

$$\frac{I K}{K G} = \frac{H L}{L G} \quad \text{Therefore } I K = \frac{K G, H L}{L G,}$$

and H L = D C + C H — G F, which are all given, and therefore H L is known;

and since K G and L G are also given, I K is known;

therefore the relief required, I E, which is equal to I K + G F, is determined.

196. When small works open at the gorge, as Redans and Lunettes are only liable to be attacked from the front, and are to be defiladed from a hill in that direction, the following plan will suffice: Let the crest of the parapet lie entirely in the plane determined by three points, of which one must be in the crest of the parapet on the hill, the other two, the extremities of the crest of the parapet at the gorge of the work.

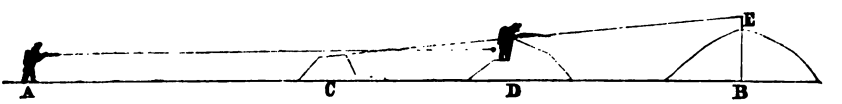
By this arrangement the work itself will be defended from the fire from the hill, and its interior will be exposed to view and fire from the ground in rear, rendering it frequently untenable, when taken by an enemy.

197. Let it be required to protect the interior of a square redoubt from the fire of a neighbouring hill situated opposite to one of its sides.

This might be effected by raising the parapet on the side next to the hill to the requisite height to protect the whole interior as in the case just cited.

and this arrangement would certainly protect the interior of the redoubt from the fire of the hill, but it would give rise to another inconvenience as great as that which was sought to be avoided; thus a

FIG. 134.



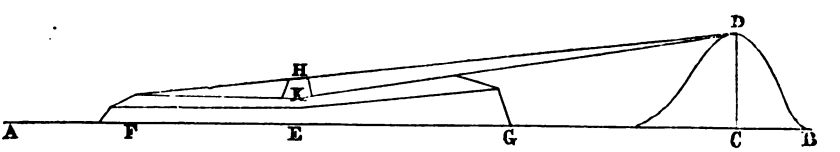
soldier at A would be able to fire over the parapet at C, and strike down the defenders upon the banquette at D.

In fact any arrangement of the crest of the parapet into one plane, by which its interior may be defiladed from E, must necessarily expose it to be seen and fired into from any point of the original plane on the side of the redoubt remote from the hill.

A different arrangement then becomes necessary; that generally adopted is this: The redoubt is divided into two parts by a vertical plane perpendicular to the line joining the centre of the redoubt and the top of the hill.

The half of the redoubt nearest to the hill must now be defiladed as above. The half remote from the hill must be defiladed by a traverse or parapet running across the line of division.

FIG. 135.



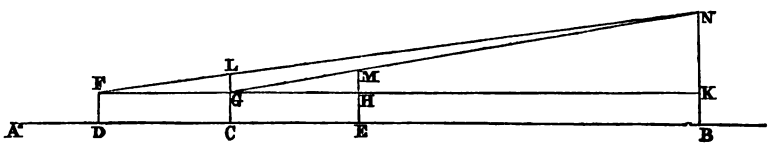
In the annexed diagram (Fig. 135) is shown the side elevation of a square redoubt defiladed in this manner. Here the nearer half, E G, of the redoubt, is defiladed from the hill by the elevation of its crest into a plane coincident with the line of fire from D to K. The further half, E F, is protected by the traverse at H, which also serves as a cover to the defenders on E G, from the fire of troops on the plane A F.

Example:—

198. To find the height of parapet to protect the nearer side of a

redoubt, and of a traverse to protect the further side from the fire of a hill.

FIG. 136.



Let A B (Fig. 136) be the plane of site, C the centre of the redoubt; D and E its two sides; D F the height of the parapet on the further side; B N the height of the hill, including the parapet (if any), on its summit.

Draw F G H K, parallel to A B; join F N, G N, and produce C G, E H, to meet these lines in L and M.

Now K N, F K, F G, G H, are given to find L G and H M.

By similar triangles L F G, N F K,

$$\frac{L\,G}{F\,G} = \frac{K\,N}{F\,K} \text{ or } L\,G = F\,G\,\frac{K\,N}{F\,K},$$

whence L G is found, and the required height of the traverse is equal to C G + L G, and is therefore found.

Again, by similar triangles, G M H, G N K,

$$\frac{M\,H}{H\,G} = \frac{K\,N}{K\,G} \text{ or } M\,H = H\,G\,\frac{K\,N}{K\,G},$$

whence H M is found, and the required height of the parapet is equal to E H + H M, and is therefore also found.

199. A redoubt could be defiladed from two hills, one opposite to each of two opposite sides, in a manner exactly similar to the foregoing, with this exception, that the crest of the parapet of each portion of the redoubt will rise from the traverse in the centre towards the adjacent hill, instead of on one side only.

It will be profitable for the student to work our examples for himself of each of these cases.

200. To find the plane of defilade practically, 1st, from one hill in front—

Set up a vertical rod at each angle of the work higher than the parapet is likely to be; take any plane surface (a surveying plane table for instance), and set it up at the gorge of the work, or at that distance in rear to which cover is required. Place one side parallel to the ground as many feet above it as will afford the requisite cover, probably about 7 feet. The plane must then be moved about this side until its surface prolonged intersects the top of the parapet on the hill from which the work is to be defiladed. This will be effected by casting the eye along the surface of the plane, and causing its further edge to appear to intersect the parapet on the hill. The plane must now be fixed in the position into which it has been moved. The officer must next place himself successively in convenient positions around the plane, and directing his eye along the surface observe where the further edge appears to intersect one of the poles set up at the angles of the work. The spot so observed must be marked by an assistant with chalk or a notch, and the same operation be performed for each pole. A line, joining the marks so obtained, will define the crest line of the parapet of the work, which will manifestly be in one plane, coincident with the surface of the plane table used in the operation.

201. To defilade the work from two hills is a very similar operation. In this case two of the three points determining the position of the plane will be the highest spot of the parapet crowning each hill. The third point will be at the gorge, or in rear of the gorge of the work, and at the requisite height above the ground. The position of the plane having been thus fixed, the remainder of the operation is performed just as in the case above mentioned.

It is obviously impossible to defilade a work from hills all around it, and a site commanded on all sides is therefore totally unsuited for a fortified position; in fact, when the hills are near or numerous, the interior will be so choked by traverses as to leave little space at the disposal of the garrison, so that positions of this character ought to be if possible avoided.

MILITARY MINING.

202. Mining is the art of constructing galleries or passages underground, placing at their extremities charges of gunpowder, and blowing

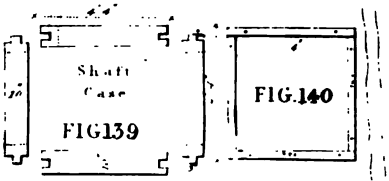


FIG.139

FIG.140

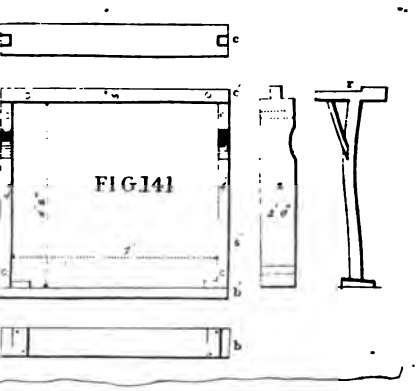
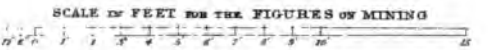
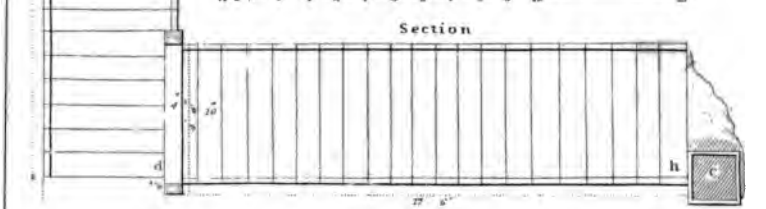


FIG.141

FIG.137.





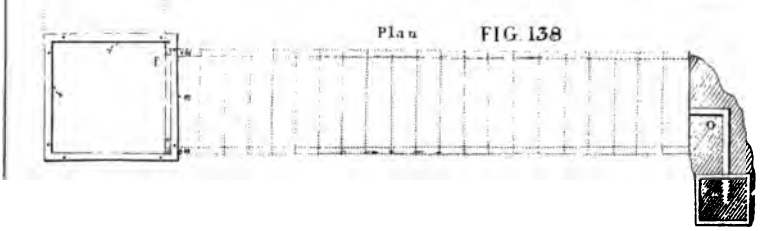


FIG. 138

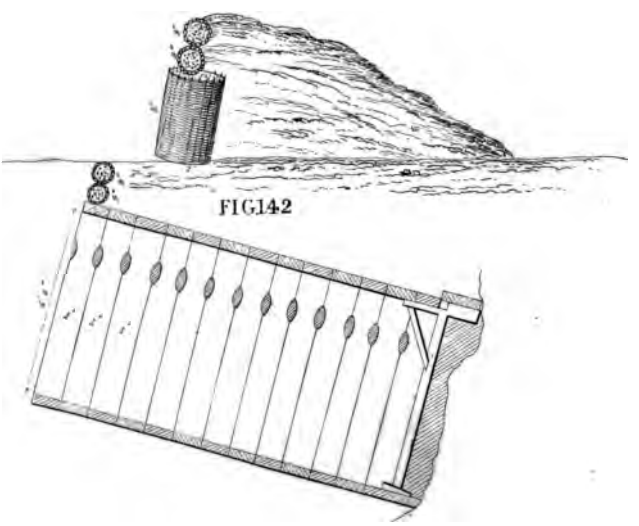


FIG.142

up an enemy's work. The principal difficulties in mining are the formation of the shafts and galleries which are frequently driven to considerable distances, 100 yards or more, and the explosion at the proper instant of the charge. When several charges are employed, as is frequently the case, their simultaneous explosion is generally requisite, and to ensure this is by no means easy.

203. There are two methods by which the charge may be laid at the required spot. One by sinking a vertical well or shaft to the requisite depth, and by driving out from the bottom of it a horizontal gallery to the required distance (Fig. 137). The other by driving a gallery in a direction inclined to the horizon, gradually descending so as to reach the required spot (Fig. 142). The latter is generally to be preferred, 1st,—as requiring less excavation; 2nd,—as easier of construction, as the earth may be wheeled out at once in a barrow, instead of being lifted by a windlass, and ingress and egress is much facilitated.

204. In either case, except in very stiff soils or in chalk, the sides of the shaft and of the gallery must be lined with planks to prevent the earth from falling in and obliterating the gallery. In chalk, elliptic galleries will stand without support, and in very stiff soils the galleries may be only partially lined.

The lining of the galleries may be done in two ways, 1st, by frame and sheeting, that is, by planks placed flat against the sides and top, retained in their places by rectangular frames set up at intervals of 3 or 4 feet; 2nd, by the more convenient method of mining cases (Figs. 139, 140). Each case consists of four pieces of plank, 10 or 12 inches wide and 2 inches thick, and in length proportioned to the dimensions of the gallery. Two pieces are morticed and two provided with tenons, and they are set up successively in the shaft or gallery as the excavation proceeds.

Descending galleries should have a depression not greater than 1 in 5, and the cases with which they are lined should be set up perpendicular to the slope of the gallery, and not vertical.

Galleries are generally made of the dimensions stated below:—

No. 1 is for descent into ditches and the passage of cannon.

„ 2 ditto ditto and passage of troops, two deep.

„ 3 large enough for the general purposes of attack; and allows the miner a free change of posture, and to work on one or both knees.

No. 4 and 5 too small to work in for a greater distance than 10 or 12 feet.

Name and description of gallery or branch.	Dimensions in the clear. HEIGHT. feet	in.		WIDTH. feet	in.
1. Great gallery	6	6	×	7	0
2. Principal gallery . . .	6	6	×	3	9
3. Common gallery . . .	4	6	×	3	0
4. Great branch . . .	3	6	×	2	6
5. Small branch	2	6	×	2	0

Great galleries can be driven in average soil, with mining cases, at the rate of 1 foot per hour, and common galleries at the rate of 1½ feet per hour.

205. In driving galleries to considerable distances, ventilation becomes necessary, or from the deterioration of the air by the breathing of the miners, they will be unable to continue their work. This artificial ventilation will generally become necessary when the gallery has attained a length of 50 feet. It will be best effected by hand bellows of a cylindrical form, and the air may be conveyed to the head of the gallery by leather tubes made in convenient lengths, with tin tubes at their extremities to fit tightly into each other. When tin tubes can be procured in convenient lengths, they will answer the purpose effectually, but will require protection, or they will be liable to be trodden upon and crushed.

The heads of long galleries will also require to be artificially lighted. This will generally be effected by lamps or candles.

When the gallery has been driven to the requisite distance, an excavation or chamber is made, usually a little to one side of the gallery, of a capacity sufficient to contain the charge of powder.

206. The Charge. The charge of powder for an ordinary mine, that is, one which will produce a crater having a diameter at the surface equal to twice the length of the line of least resistance, *i.e.*, the depth of the charge below the surface, may be found by cubing the line of least resistance expressed in feet, and dividing by 9, the result is the number of pounds of powder necessary.

The charge must be placed in a box of stout deal or other available wood, not less than 1 inch thick, which has been previously made watertight by a coating of tar.

207. A powder hose must now be prepared by which the charge may be fired. This will generally be formed of a stout close tape, at least an inch in width, closely sewn together at the edges, to form a tube. This tube must be carefully filled with powder, and care must be taken in the operation that the tube may be full enough that in bending no part may become vacant, and not so full as to risk bursting. A piece of half-inch gutta-percha tubing would make an excellent powder-hose.

In placing the charge the greatest precautions must be taken. Too much care can scarcely be exercised. If carried on a truck it should have wooden wheels with copper rims. The non-commissioned officer of the mine should advance with the charge, followed by the officer at a distance of 20 feet, carrying a strong reflecting lamp. On reaching the chamber, the officer hands the lamp to his assistant, and proceeds to direct the placing of the charge and the laying of the hose: the latter must be secured in a casing tube, the lid of which is pegged down, and immediately afterwards covered over with 6 inches of mould. In doing this a copper shovel should be used.

All persons employed in the loading, should either be without shoes, or they should have worsted shoes or stockings over their shoes. The lights should be all removed, and all the men ordered out of the gallery except those employed in loading. The greatest attention is necessary to secure the end of the hose or fuse within the box or bag. If a box be used, the end of the hose should be passed through a hole on the top of the box, and a wooden skewer run through it, to prevent its being drawn out accidentally. The end of the hose should be sewed up to prevent its wasting powder.

208. Tamping. The gallery must now be tamped, that is, filled up with resisting materials to a distance equal to $1\frac{1}{2}$ times the length of the line of least resistance, so that the effects of the explosion may not find vent through the gallery. The mining cases should be removed from the portion of the gallery to be tamped, and earth rammed well in, which may be obtained from short branches run out from the sides. The resistance of the earth will be considerably increased by bars or beams placed across from side to side, buried in the mass of the tamping. Filled sand bags, to contain half a bushel of earth, are very handy, and constitute an excellent tamping.

209. The mine will be fired under ordinary circumstances by a fuse, or port-fire, attached to the extremity of the powder hose. The length

of this fuse must be proportioned to the time which it is desired should elapse between the firing and the explosion of the charge. In cases where the gallery or hose is short, the port-fire must be long enough to allow of the escape of the person firing, before the explosion occurs.

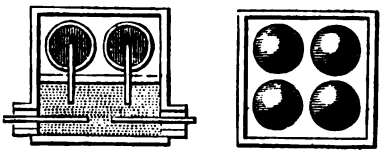
210. A great improvement on the ordinary powder hose and port-fire is that material known as Bickford's Patent Fuse. This fuse is a small tube of gunpowder, bound round with tarred twine, and coated with a varnish rendering it impervious to moisture. It burns with certainty, even under water, at the rate of about 12 feet in five minutes. This slow rate of burning is the only objection to it for the explosion of military mines. To explode small charges, where a long train is unnecessary, to ignite powder bags attached to gates, and for such like purposes, it is invaluable.

211. A more certain method, when circumstances permit, especially for several charges, is by the use of the galvanic battery. When a current of galvanic electricity is passed through a wire, it has the property of heating to redness any portion of the wire, which may be very much reduced in thickness. A piece of fine platinum wire is passed through a small package containing an ounce or so of gunpowder, and each extremity is attached to a copper wire coated with an insulating compound (gutta percha, for instance, would answer admirably) one-fifteenth or one twentieth of an inch in diameter. The small charge of gunpowder is placed in the centre of the large charge, and the wires are conducted to the exterior of the mine. When the explosion is desired, the copper wires are connected with the poles of the charged galvanic battery, the platinum wire is immediately heated to redness in the centre of the charge, and the explosion ensues. This method is applied with great certainty to explosions under water.

212. Charges of gunpowder are frequently placed at the bottom of a pit or shaft dug in the ground over which an enemy must pass to the attack. In these cases they take the name of fougasses. The chief difficulty attending the use of fougasses is to explode them at the instant when the enemy is passing over, as any variation in the time of explosion from this instant renders them altogether useless. It is, therefore, recommended to place an obstacle over them, as an abattis or chevaux-de-frize, so that the fougasses may be exploded while the enemy is occupied in forcing his way over.

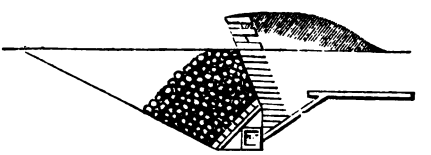
Sometimes a fougass is made of several loaded shells placed in a box, with a charge of powder under. The box should be pitched to keep the charge dry (Fig. 143).

Fig. 143.



A stone fougass (Fig. 144) is made by excavating a shaft 6 feet deep, inclined to the horizon at an angle of about 45°. At the bottom place a charge of 55 lbs. (a cubic foot) of powder, then a strong shield of wood at least 6 inches thick, in front of the charge, and over the shield throw in three or four cubic yards of pebbles, of not less than half a pound weight each. A sufficient body of earth must be placed vertically, above the charge, and retained over the upper part of the shaft, near the edge, by a revetment of sods, to insure the effect taking place in the right direction.

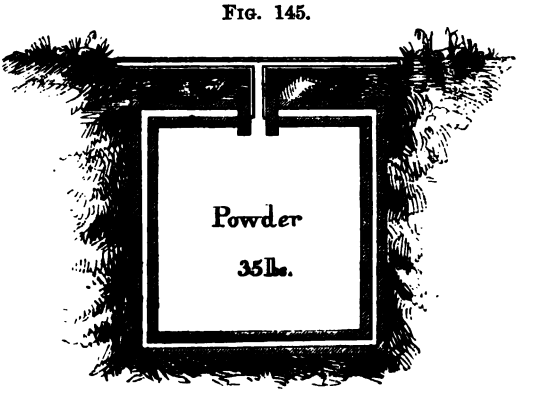
Fig. 144.



Fougasses are usually fired by means of an augot, or casing tube, containing a hose or saucisson, &c., led up the side of the pit or shaft, and then parallel to the surface of the ground, at a depth of two or three feet, or they may be fired, at the proper moment, by means of a loaded musket with its muzzle in the powder, and a wire or string fastened to the trigger.

213. Analogous to fougasses were the Russian powder-boxes used

Fig. 145.



at Sebastopol. Each consisted of a double deal box, of a capacity

sufficient to contain 35 lbs. of powder, watertight, and effectually secured from the penetration of damp; into the top of each box was inserted a vertical tin tube, connected with a horizontal tin tube at the surface of the ground. Within the latter was a glass tube, filled with sulphuric acid, and coated with a composition of chlorate of potass, sugar, sulphur, and gum water, which immediately takes fire on coming in contact with the acid. The space between the interior of the tin tube and the exterior of the glass tube, as well as the vertical tin tube, is filled with gunpowder. A little earth spread lightly over the whole completes the arrangement.

A person walking over the ground, and treading on the tin tube, crushes it and the glass tube contained in it, causing the escape of the sulphuric acid, and the explosion of the gunpowder.

214. Charges of gunpowder are used to force open gates, to burst breaches in brick walls, or in stockades, &c. For this purpose it is sufficient if the charge, which will vary from 50 to 200 lbs. according to the strength of the obstacles, in bags, be placed against the obstacle, and fired by a piece of Bickford's fuse, 5 or 6 feet in length. A charge of 50 lbs. in a bag hung against a gate, on a gimlet, will be sufficient to destroy it. From 100 to 200 lbs. placed against the foot of a massive stockade, will produce a practicable breach. In this case the effect may be, perhaps, increased by a few filled sandbags laid over the charge.

COUNTER-MINES.

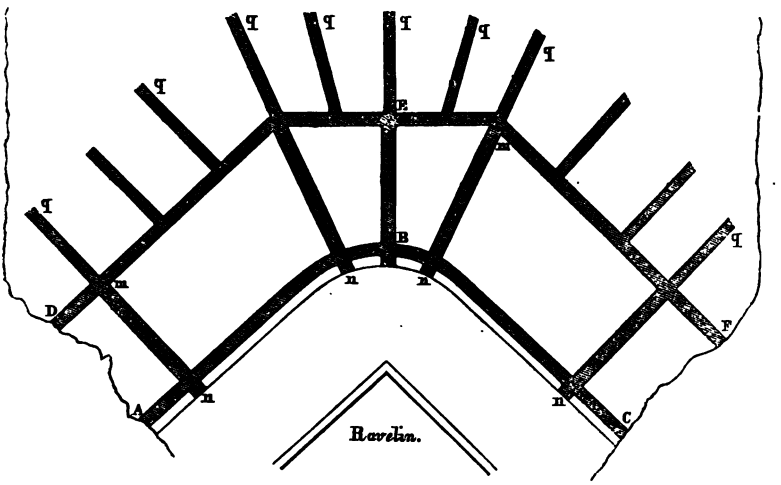
215. A system of countermines is a series of masonry galleries at small intervals, under the glacis of a fortress, enabling the defenders to explode charges of powder beneath, and so to destroy the works of a besieger, should he attempt to carry them up the glacis, without previously destroying the countermines.

Many systems of countermines have been invented, some very elaborate, consisting of several stages of galleries, one over the other, with the intention of blowing up the ground several times in succession. With the systems of attack in use at the present time, viz., by the explosion of very large charges of gunpowder, called globes of compression, compressing the ground to very great distances from the focus of the charge, these elaborate systems present no advantages,

as the galleries in the several stages would be destroyed simultaneously.

216. A system of countermines of a single stage at a moderate depth below the ground, is now generally recommended. Such a system before the salient of a ravelin is shown in Fig. 146, *n n n n*

FIG. 146.

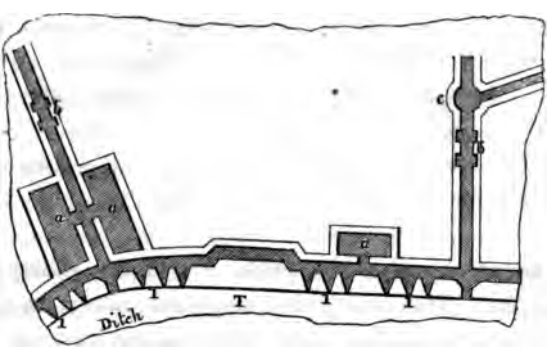


being the counterscarp of the ditch, A B C the gallery under the covered-way, &c. This principal or magistral gallery, or, as it is more frequently called, the gallery of the counterscarp, serves as the base of a system of counter-mines. It is represented by the double-shaded line A B C. That which is parallel to it, and beyond it, D E F, is the envelope gallery; those galleries which connect these parallel galleries, as *m n*, *m n*, are galleries of communication; and all those pushed into the country beyond the envelope gallery, as *q q q*, are listening galleries. The galleries of communication open into the ditch by arched passages in the counterscarp revetment at *n n n n*.

217. The situation of the magistral or counterscarp gallery in some systems is immediately under the banquette of the covered-way; in others, under the terre-plein of the covered-way; and in some immediately behind the counterscarp revetment: the last is generally considered the best situation for it, as masonry is thereby economised; for the revetment itself forms one side of the gallery. The gallery also is better lighted and aired by the doors and loop-holes looking the ditch; and, lastly, it is as far removed as possible from the effects of the

enemy's globes of compression. In this situation it is more especially called the counterscarp gallery. In the construction of the counterscarp gallery, the revetment is built without counter-forts. In this revetment loop-holes are pierced in order to get a reverse fire of musketry into the ditch, as well as to light and air the gallery. Strong massive doors secure the openings into the ditch, through the counterscarp: these are made opposite to the galleries of communication. Small magazines are formed in considerable numbers, principally at the entrances of the galleries, to contain the miners' tools, timber for forming branches, sand-bags, &c., used in tamping: the best and driest of these recesses are used as magazines for the powder required for the mines. In Fig. 147, *l l l* is the ditch; the shaded parts are

FIG. 147.



the galleries, with loop-holes looking into the ditch, made through the counterscarp. The revetment is increased in thickness, under the traverses of the covered-way, as at T. The counterscarp gallery has always the dimensions of a great gallery: that is 7 feet wide by 6½ feet high.

218. D E F, Fig. 146, represents a continuous envelope gallery, from which listening galleries, *q q q*, are extended even beyond the foot of the glacis. This is considered a faulty construction, as the envelope gallery presenting its side to the action of the enemy's globes of compression is certain of speedy destruction. A better arrangement is that shown in Fig. 148. The envelope gallery, or the portions of it which may be necessary, should have the dimensions of a principal gallery, viz., 6½ feet high by 3 feet 9 inches wide.

219. Galleries of communication, *m n*, *m n*, Fig. 146, are always

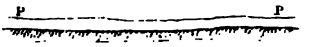
formed, whether the envelope be continuous or not, and, that they may answer their name and purpose, they should have the dimensions of principal galleries. At frequent intervals, grooves are made in the masonry walls of these galleries, and of all galleries, as *b b*, Fig. 147, that the communication may be cut off by a barrier of beams and sand-bags, should the enemy have gained the envelope gallery; and when it is necessary to fire a mine without loss of time, these little barriers assist in the tamping. Strong doors, having loop-holes for pistols, should close the junctions of all the galleries, that there may be the means of resisting the sudden irruption of the enemy's miners. In Fig. 149, let *b* represent a branch running out at a right angle to the gallery; a door covered with sheet-iron, with three loop-holes for muskets or pistols, slides from *a* across *b*. A transverse section is shown in the upper part of the figure.

220. Listening galleries are to enable the defenders to advance under ground to the foot of the glacis, or even beyond it, in order to discover the enemy's miner at work, by listening attentively with the ear applied to the soil.

It is generally considered that an enemy's miner at work in earth of common tenacity may be heard at a distance of 90 feet: consequently listeners should not be farther from each other than 180 feet, that an enemy may not be able to run a gallery between them without being heard: but this is not the only consideration that regulates the intervals of the listeners. Besides giving notice of an enemy's approach, they are intended to be used as mines in the active subterranean defence. For example, let the shaded arches in Fig. 150, represent the sections of two consecutive listeners having a line of least resistance of 18 feet. Then, if they be 36 feet apart, two lined charges deposited in them will raise all the ground contained between them. But it is to be remembered that the compressing effect of such charges extends laterally to a greater distance than once and a half the length of the line of least resistance; therefore, if the listeners be about 54 feet apart, with a line of least resistance of 18 feet, a two lined charge in each will destroy any gallery an enemy might attempt to drive between them; and should chambers be formed for the charges in small returns or branches (as seen at *r r*, Figs. 148, 150), the intervals of the listeners may be increased by the length of these branches or returns *r r*, at the extremity of which the charges are lodged. Consequently, the distance between the listeners depends,

not only on the nature of the soil conveying the sound, but likewise on the depth of the charges below the surface of the ground. In Fig. 150 the listeners are 75 feet apart; and, if the line of least resistance of the outer line of defensive mines be 12 feet (as at Z, Fig. 151), two consecutive explosions of two lined charges will compress the earth to a distance of 20 feet on each side; and two lined charges are seldom exceeded by the defenders, as greater charges would, in most cases, injure their own galleries; hence, the returns *r r*, in Figs. 148, 150, must each be 17½ feet in length, that all the ground between them may be shaken. As listeners offer their points or ends to the approach of an enemy, they are most favourably situated for avoiding the destructive effects of his globes of compression. Whenever the defender ascertains that the assailant is preparing a charge at a distance, it is recommended not to use the most advanced mines in a fruitless endeavour to crush him, but to make cuts or galleries across them, with a view of lessening the effects of the explosions (part of the force of which may lose itself in these recesses), and thus to seek to parry the first blow: but as soon as the charge has been fired, when the full extent of the evil has been ascertained, and the exact route of the enemy's miner discovered by his vast crater, the offensive is taken immediately, by forming mines at the points of the listeners nearest to him; or by running out branches so as to crush his new galleries or retard his progress. If listeners have the dimensions of common galleries, $4\frac{1}{2}' \times 3'$ they will answer all the purposes just detailed, and they can then be tamped more quickly than if larger. It is customary to leave unfinished oblong or arched spaces in the masonry piers of these galleries, where branches are likely to be run out, which are executed in the usual manner, and lined with mining cases.

221. Thus the defenders secure to themselves the means of forming mines, wherever circumstances may render them requisite: but in their arrangement, it is necessary to be careful, that the innermost mines do not, by their explosion, entail the ruin of the crest of the glacis, and leave the covered-way and part of the scarp revetment exposed. Whatever may be the depth of the defensive mines, they should be arranged as in fig. 151, *i.e.*, on an inclined plane C Z, sloping gently upwards towards the foot of the glacis, the extremity of the most advanced listener being 6 feet higher than the counterscarp gallery—a sufficient inclination to admit of easy draining.



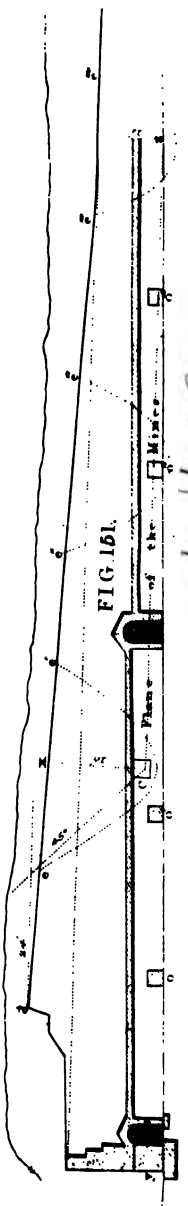


FIG.151.

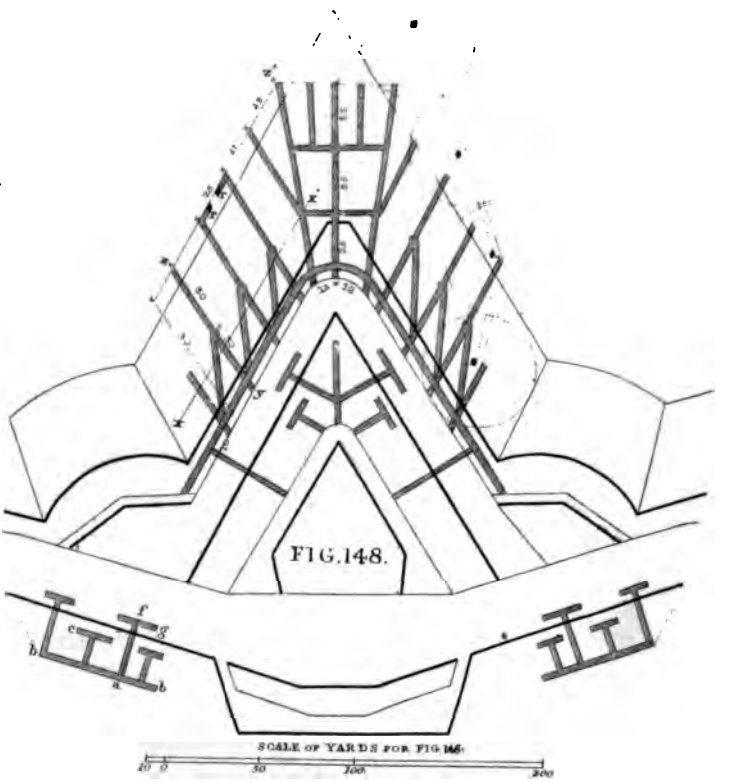


FIG.148.

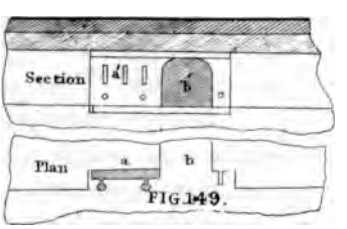


FIG.149.

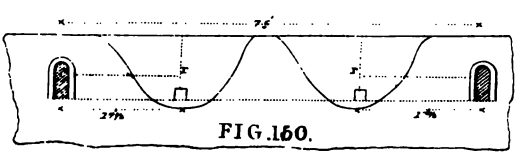


FIG.150.

The inner line of mines is intended to destroy the enemy's breaching batteries, which will be established on the crest of the glacis, should he be so imprudent as to construct them before securing himself under ground. The charges of these mines must be placed at such a distance in front of the counterscarp, that, after their explosion, a sufficient thickness of parapet may remain to screen the covered-way. If the charges be placed 18 feet below the surface of the glacis, as in fig. 151, and two lined charges be used, the exterior edge of the crater will be a circle of 18 feet radius, with its centre vertically over the charge. Wherefore, in order that a thickness of parapet of 24 feet may remain after the explosion, to screen the covered-way, the charge must be at a distance of 24+18=42 feet in advance of the crest of the glacis.

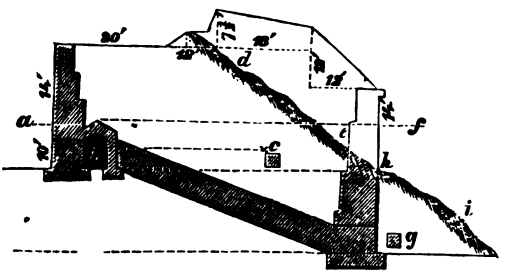
At the junctions of the galleries, as at A, fig. 151, well-arched enlargements are made; higher than the other parts of the gallery, and sometimes aired by funnels communicating with the ground above. These enlargements will be found useful for a variety of purposes, enabling workmen to pass with freedom, and serving as depôts for tools, and earth for the filling of sand-bags. They should always be made at intervals, in long galleries, whether crossed by others or not.

222. In applying the foregoing principles to a system of defensive mines on a front of fortification, traced according to the modern system (as in plan fig. 148, and section fig. 151), the dimensions and saliency of the ravelins are so great, as to throw the ground before the bastions, into contracted and re-entering spaces between them. It would, therefore, be needless to multiply costly galleries before the bastions, where the enemy does not attempt to establish himself, till the besieged are driven from the outworks. They would then be confined to the enceinte, and unable to communicate with the counterscarp gallery without great risk, unless there be a gallery of communication under the ditch, a rare construction. The chief subterranean defence, is therefore shown here, before one of the ravelins. The tracing of the galleries in fig. 148, combines the leading features of the systems of Lebrun and General Marescot.

223. The usual arrangement of the defensive mines in the bastions, is that shown in fig. 148. The escarp gallery *b b* is about 22 yards in rear of, and parallel to, the revetment of the faces of the bastion; a section on *a f* (fig. 148), is seen in fig. 152: *b b* (fig. 148) serves as a base, from which to run out the branches, and to form mines *g* and *c*:

the first, under the rubbish of the breach, at the foot of the scarp, the

Fig. 152.



second, under the rubbish, about half-way up the breach. Corresponding arrangements may be seen for the ravelin in fig. 148.

224. On the attack of a system of counter-mines. The great listeners are generally pushed, to, or a little beyond, the foot of the glacis, where the enemy establishes his last parallel of attack; but if he should be aware of the existence of the defensive mines, he will form this parallel P P, Fig. 148, at 150 feet, or more, beyond the foot of the glacis; and will direct branches upon the points of the advanced listeners, till he arrives within about 90 feet of them; he will there give his chambers a depth of about 22 feet, and will charge them with 3,000 or 4,000 pounds of powder. The effects of these surcharged mines extend horizontally to four times the length of the line of least resistance, and the extremities of the advanced listeners will be destroyed by their explosion. From these vast craters, thus formed, he will advance simultaneously on every side, to prepare for similar explosions; and by the fourth explosion will probably succeed in destroying all subterranean defence, and in blowing in the counterscarp; as indicated by the dotted circles in Fig. 148, between the parallel P, and the counterscarp of the place.

Although globes of compression, or surcharged mines, thus place great power in the hands of the assailant, it is to be remembered, that even expert and bold miners cannot proceed in their work of driving galleries, at a greater rate than from 14 to 20 feet in twenty-four hours; consequently, a considerable delay is experienced by the assailant on pushing on his attack above ground. For example, take the four galleries for the globes of compression, from P to the counterscarp, they measure together about 400 feet; which, at the rate of 20 feet in twenty-four hours, will consume a period of twenty days (ex-

clusive of the time taken in preparing the chambers, tamping, &c.): and there is no way of abridging this work, as it is impossible for more than one man, or, at most, two men, to excavate at the head of a gallery at the same moment. The assailant then advances as rapidly as one active expert man can remove away the soil before him in a small gallery. He proceeds with his trenches and attack above ground, at the same rate as he secures himself below; and requires, therefore, twenty days to work up from the foot to the crest of the glacis, instead of six, which may be considered a fair allowance for advancing the same distance in the attack of a front without counter-mines. Fourteen days are thus added to the duration of the siege, even supposing the attacking party to possess great means, and to conduct it with skill and vigour, without which the delay would be greater.

CHAPTER IX.

POLYGONAL SYSTEMS.—PRUSSIAN SYSTEM.—FORT ALEXANDER.—COBLENTZ.

225. The general principles of the bastion tracing have already been discussed at some length in a previous chapter, where it will be seen how entirely the dimensions of the several parts of the enceinte, its relief and the width of the ditch, are dependent upon each other; so that, any one dimension being fixed, limits are at once assigned to the magnitude of every other part. It will be seen, too, that the advantages of the whole arrangement are altogether dependent upon the effectual flanking of the ditch by the musketry fire of the flanks, and that the range of musketry thus becomes the standard by which the limits, between which the magnitude of the several parts of a front may be allowed to vary, are definitely fixed.

With the present greatly extended range of musketry, this is of less importance than formerly, as fronts can now have an extent sufficient for any purposes that may be required. Until recently the extent of a properly-arranged front could scarcely exceed 400 yards. To obviate this and many other defects, apparent in the bastion tracing, the polygonal, or German systems were introduced.

226. In these systems, the defence of the ditches is entrusted to artillery, instead of musketry; and as the range of grape far exceeds that of the old muskets, the limits to which the fronts may be extended are increased in a corresponding degree. The guns for the defence of the ditches are placed in separate casemated works, called caponnieres, where they are protected from an enemy's distant fire; and as their only object is the defence of the ditch, they need not be put in position until the latter part of a siege.

THE PRUSSIAN SYSTEM.

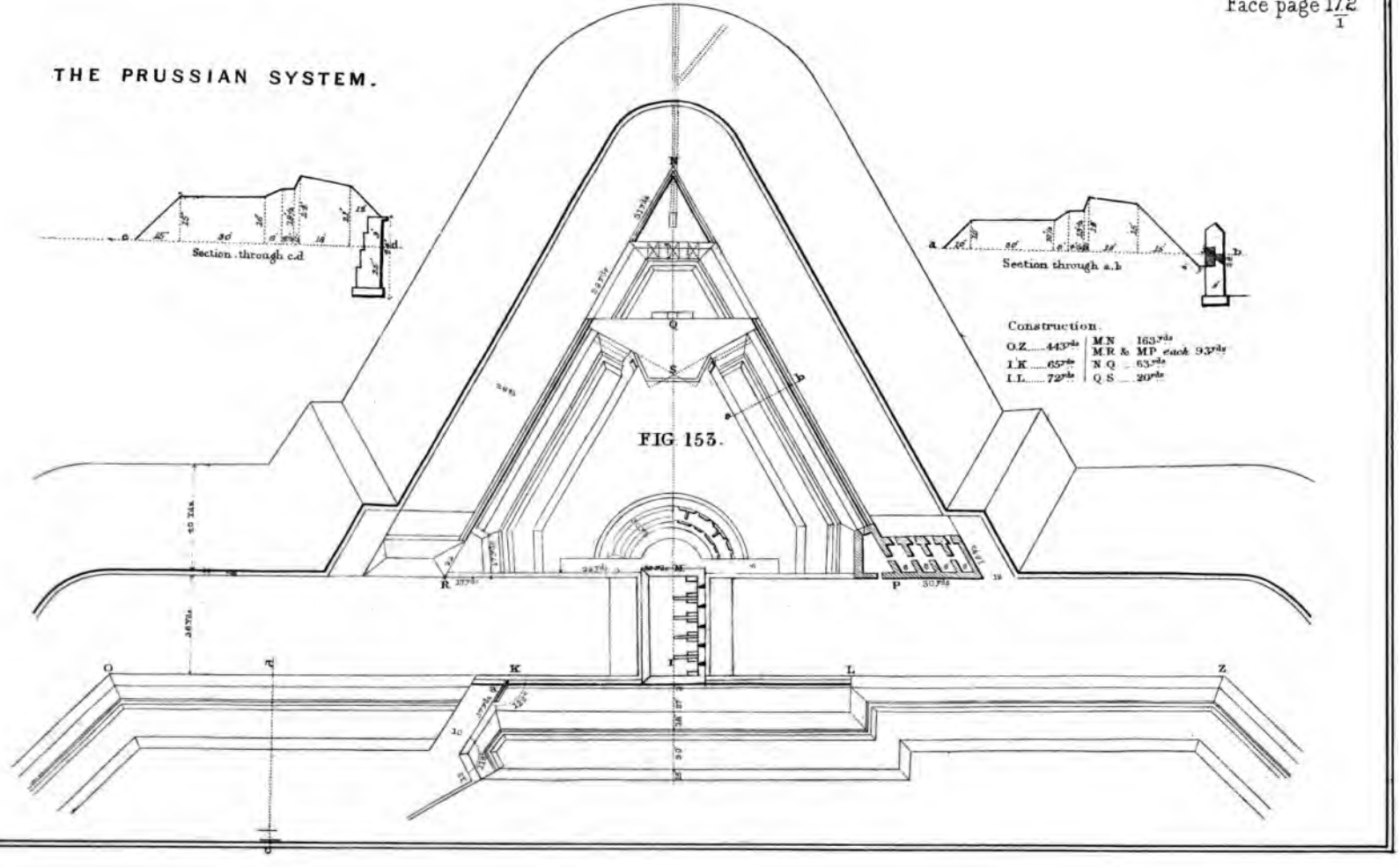


FIG. 153.

FIG.154. Longitudinal Section through the Caponniere in the main Ditch of the Prussian System.

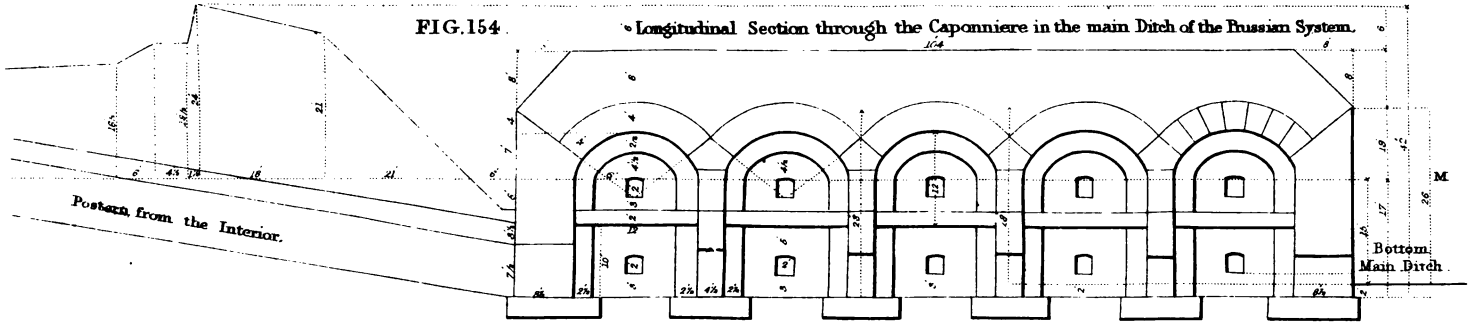


FIG.155. Section on the Capital of the Ravelin at the Salient angle of the Prussian System.

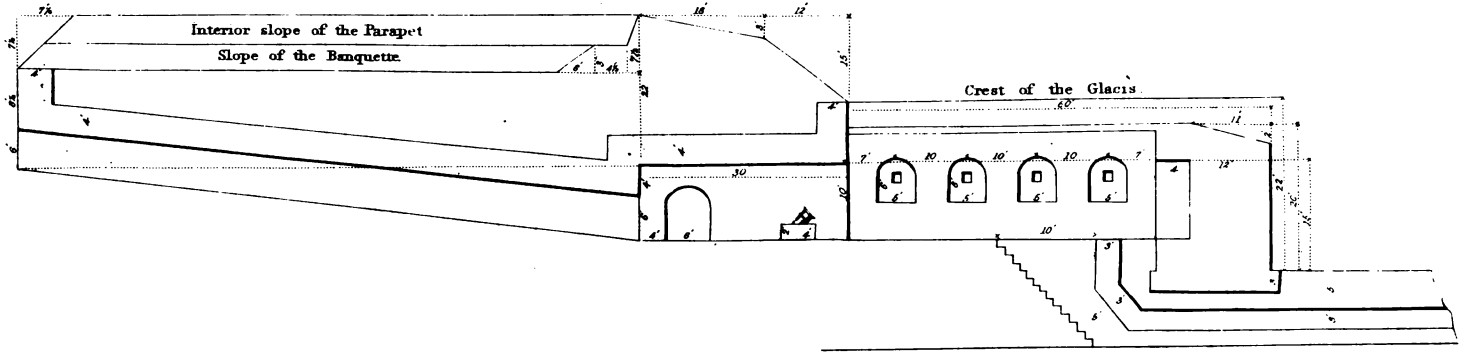


FIG. 154. Longitudinal Section through the Caponniere in the main Ditch of the Prussian System.

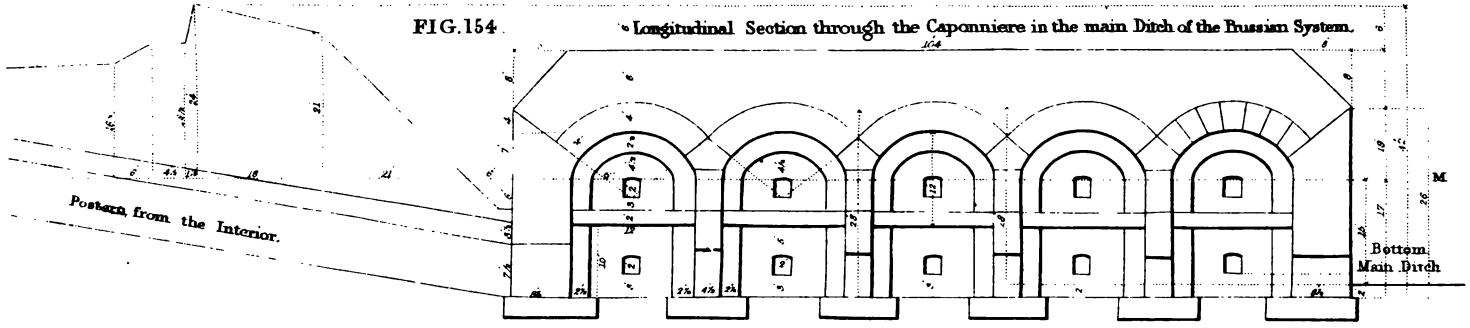
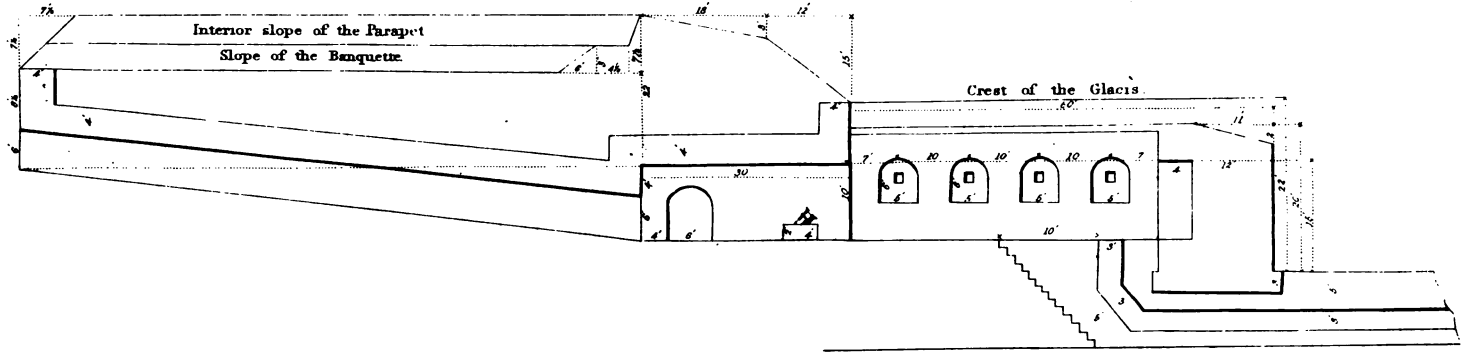


FIG. 155. Section on the Capital of the Ravelin at the Salient angle of the Prussian System.



Transverse Section through the Covered Caponniere — Prussian System.

FIG. 158.

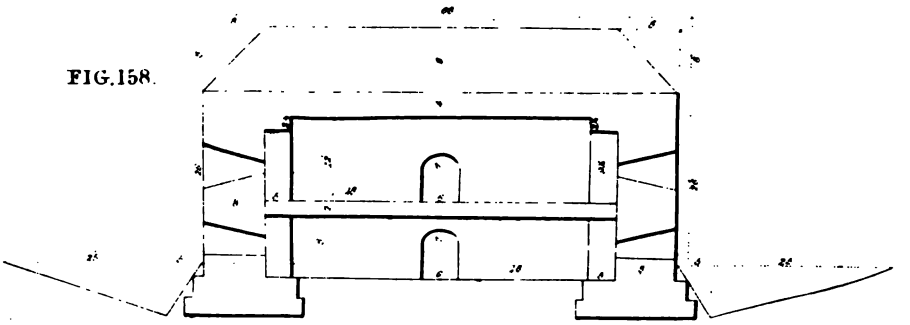


FIG. 157.
Casemated keep or Hall Tower in the Ravelin of the Prussian System.

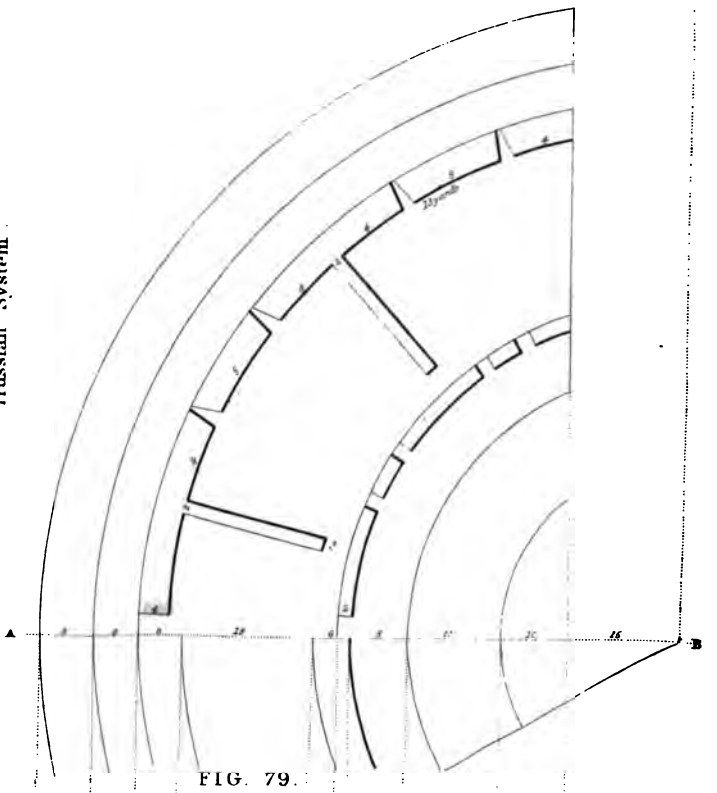
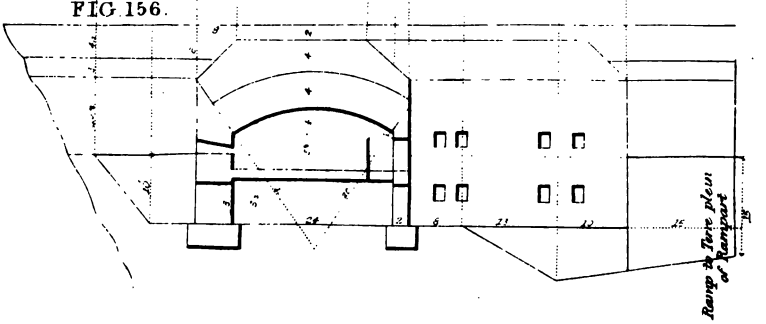


FIG. 79.
Section on A.B. of FIG. 157.

FIG. 156.



The defence of the ditch being provided for by the casemated caponnieres, the necessity for breaking up the outline of the enceinte into a succession of salient and re-entering angles, as in the bastion tracings, is altogether removed. The enceinte may, therefore, have that outline which in the particular case is most advantageous for defence, and best adapted to the natural features of the position. This will generally be a polygon, more or less regular, according to the regularity or irregularity of the site.

The caponnieres for the defence of the main ditch may either be on the centre of the front, as in Fig. 153, or at the alternate salient angles; the latter, as being more secure from an enemy's distant fire, appears the better position.

227. The Prussian system (Fig. 153) is an illustration of the polygonal tracing. Its construction is sufficiently given in the plan, Fig. 153, and sections, Figs. 154 to 158.

The length of the exterior side may be of almost any magnitude, though 600 yards is, perhaps, as great as under any ordinary circumstances would be requisite. The enceinte is a massive rampart and parapet, fronted by a revetment, from 24 to 30 feet in height, which is sometimes wholly or partially loop-holed for musketry. In Fig. 153, the central portion of the revetment, from L to M, has this construction. Coupure retrenchments can be made in the enceinte, as shown at K.

The centre of the ditch is occupied by the casemated caponniere, L M, a massive work of masonry, shown in section by Figs. 154, 158, capable of containing two stages of five guns each, one on either face; so that the ditch on either side of the caponniere is swept by the fire of ten guns.

The front is here provided with a ravelin of great size, its projection being sufficient to protect the adjacent fronts from enfilade fire. A casemated caponniere, of a construction similar to that already described, closes the trouée of the ditch of the ravelin on either side, and sweeps it by a powerful fire. A bastion retrenchment, from points on the faces about 70 yards from the salient angle, separates the advanced portion of the ravelin from the remainder. On this portion, the relief of the parapet is the same with that of the enceinte, sufficient to protect the faces of the ravelin, and in a great measure the fronts of the enceinte, from enfilade fire. The rampart and parapet does not extend to the salient of the ravelin, but passes across the capital of it at

right angles, at a distance of about 27 yards from the salient. Under this parapet are casemates for three mortars, which, together with the fire from the parapet above, directly oppose an attack on the salient of the ravelin. The ground in front of this parapet, up to the salient of the ravelin, is enclosed by a loop-holed wall.

At the gorge of the ravelin is a masonry keep or tower, of a semi-circular form, shown in plan and section by Figs. 156, 157. It contains two stages of guns in casemates, which are able to sweep the whole interior of the ravelin by their fire.

228. The advocates for this system claim for it the following advantages:—

1st. When the range of musketry is given up as the standard length of a line of defence, and that of artillery substituted for it, the exterior sides of the polygons of fortification may evidently be much extended. The length of the side of the polygon in this plan is 443 yards; but it might be much greater if necessary, when the ditches are defended by guns in great casemated caponnieres.—2nd. The Prussian engineers prefer the construction of casemated flanks for the defence of ditches, as being more secure than the ordinary flanks of the bastion system; that is, the guns are protected from enfilade and vertical fire from a distance, and cannot be counter-battered by direct fire, until the assailant crowns the glacis. In this plan there are caponnieres for the defence of the main ditch, and for the ditches of the ravelin.—3rd. The ravelins can be made as salient as the detached ravelins of Chasseloup and Bousmard; while the caponnieres or casemated projections by which their ditches are defended, protect the body of the place from the breaching batteries of the enemy on the counterscarp, at the salient angles of the ravelins. These ravelins are more under the fire of the enceinte, than detached ravelins; they contain a greater interior space; there is a saving of masonry at the gorge: and fewer troops secure the work from assault.—4th. In the attack of these fronts, the approaches are opposed on the capital of the ravelin, by three mortars in casemates under the parapet, cutting off the salient of the ravelin, and by guns on the terre-plein above. The glacis is protected on each side, by the fire of 90 yards of the enceinte, and from 80 yards of the faces of the ravelin, which (being covered by the advanced portions of greater elevation) is very difficult to enfilade. —5th. The establishment of batteries on the counterscarp of the salient angle of the ravelin, is rendered very difficult by counter-

mines, and by a double tier of fire along the whole width of the ditch, viz., from the caponniere and from the enceinte behind it; even supposing this caponniere to be silenced, its massive ruins would prevent a serious breach being made in the enceinte.—6th. The attempts of an enemy to lodge himself on the advanced part of the ravelin are opposed by counter-mines, prepared in the work during its construction, and by the retrenchment behind: moreover, any endeavour to establish a battery in the narrow part of the angle, would be opposed by the fire of the whole enceinte behind the ravelin; —by that of the casemated keep;—and by sorties having their flanks fully protected.—7th. The permanent possession of the ravelin can only be obtained after the destruction of the keep (which commands every part of the interior, and is not seen from the exterior): and until this is accomplished the enemy cannot make his approaches on the glacis, for the purpose of constructing his breaching batteries against the enceinte; or he would be taken both in flank and in reverse.—8th. The great caponniere flanking the ditch of the enceinte is independent of the keep of the ravelin (which after being taken would be open to the fire of the enceinte and its detached escarp); while its double tier of guns, sweeping the whole width of the ditch, can only be opposed by batteries directly in front. The establishment of these batteries, and of others for breaching the escarp at the salient, would, of course, require the capture of two ravelins, between which the approaches would be sheltered from the collateral works; but the ground would be diminished in extent on advancing near the place, and consequently expose the troops (concentrated in larger numbers) to a more destructive fire.—9th. From the great projection of the ravelin, and the obtuseness of the angles of the polygon, the effects of ricochet on the enceinte are prevented in an octagon, as the prolongation of the sides of the polygon, or the enceinte, are intercepted by the ravelins; which ravelins might (in cases where the ground is favourable) be made to project still further, so as to cover the ditch from enfilade by distant batteries, and thus secure the great caponnieres from annoyance.—10th. The salient angles of the enceinte may also be retrenched by a detached loop-holed wall, which would bring a great extent of fire on the breach.—11th. The Prussians consider that, by these arrangements, they obtain much superiority over the ordinary bastion systems, including those of Bousmard and Chasseloup de Laubat. That greater means of resistance are obtained

at a comparatively small expense, which means might be increased when required, by cavaliers, by interior retrenchments, and by a covered way, with redoubts.—12th. The armament required would be comparatively small, as in the flanks or caponnieres, which completely enfilade the main ditches at a short range, a few pieces only would be necessary to prevent a coup-de-main, while a full supply to resist a serious attack might be brought by easy and secure communications. A few guns placed on the salients of the ravelins would be sufficient to keep off an enemy until he had broken ground; while the whole disposable guns of the place might easily be brought upon the enceinte on that side, and the second part of the collateral ravelins.—13th. The fatigue attending the usual arrangements would also be greatly diminished by the easiness and security of the communications. The garrison need not be numerous, as they are not required to expose themselves in outworks beyond the main ditch; they are protected by casemates in the flank defences, which are sufficiently strong to allow of their concentrating nearly the whole force on the points of importance, and which, being concealed from the enemy, do not give known points to his vertical fire.

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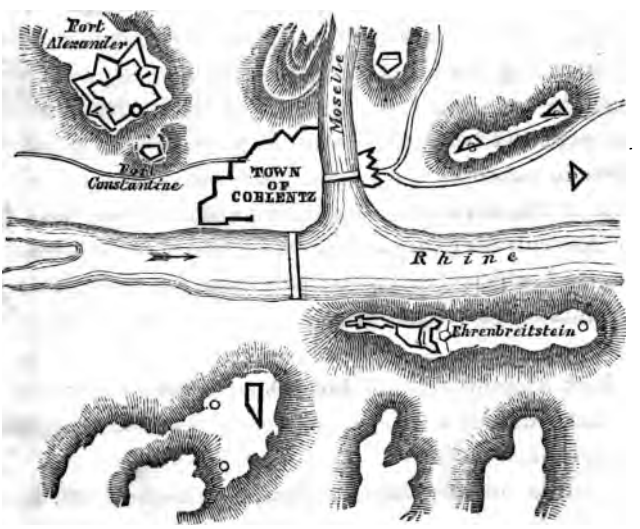
229. Fort Alexander (Fig. 160), which crowns a height commanding the town of Coblentz (Fig. 159) is a beautiful specimen of the German system.

The position around Coblentz occupies the four opposite angles, made by the Moselle and the Lahn, which rivers empty themselves into the Rhine, nearly opposite to each other; for the Lahn runs into the Rhine about a league above Coblentz. The general form of the ground is very favourable for the offensive or defensive operations of an army in posesssion of it, and its fortresses; and many of the high roads from the most important towns in Germany pass in this direction; whilst the country is so difficult of access, that it is next to impossible to avoid the main road. Coblentz is situated in the angle formed by the junction of the Moselle with the Rhine. It extends about three fourths of a mile in each direction.—The enceinte of the town is secure against a coup-de-main. Its rampart forms a succession of salient and re-entering angles, which being obtuse are little liable to enfilade; while the ditches are flanked by good casemated batteries, having three guns in each flank. The gateways are strong casemated barracks, containing batteries to flank the ditches and approaches.

These casemates are separated from the ramparts on each side, and form a kind of citadel: the profile of the rampart is nearly similar to Carnot's: the wall is well covered. Should the neighbouring works on the heights be reduced, the town would be commanded and exposed to an enemy's fire. It is, however, no easy matter for an enemy to get possession of these commanding sites. The two most important of these are, Ehrenbreitstein on the right bank, and Fort Alexander on the left bank, of the Rhine.

FIG. 159.



230. Ehrenbreitstein occupies a commanding rocky site, 400 feet above the river, inaccessible on three sides, and on the approachable side from the north, it is defended by strong double works; having abundant casemates for its garrison, stores, and artillery. It is the key of the whole position, commanding all the surrounding works within its range, and having smaller works detached from it, for looking into hollows, that cannot be seen from the main works. It has a fine well, 300 feet deep. The faces of the works defending the only approachable side, can mount forty-three pieces of ordnance in casemates; the ditches are well defended by casemated batteries; and the escarps are about 35 feet in height. It is altogether a most formidable work. The piers that separate the casemates and support the arches are made to project right through to the front of the revet-

ment, which is 10 feet thick: and the courses, instead of being horizontal, are laid in successive arches, the joints forming rays from a centre. The whole is built of rough stone, and grouted in, so as to settle in time into a solid mass.

231. Fort Alexander with its dependencies, commands all the approaches to Coblentz between the rivers. The principal front of this work has its exterior side, A B (Fig. 160), about 650 yards, and its interior side, *a b*, about 500 yards in length. By the inspection of

Fig. 161.

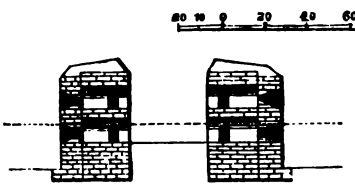


Fig. 162.

Fig. 163.

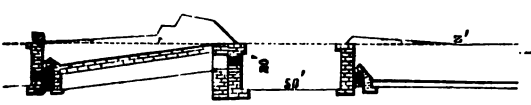


Fig. 164.

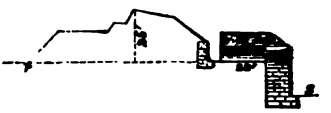


Fig. 165.

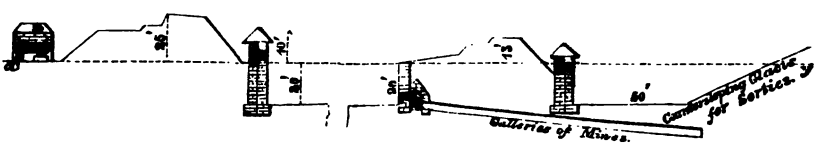


fig. 159 it will be seen that (with the exception of one) the ravelins and the counterguards have their faces directed so, that their prolongations do not fall upon the plateau in front, but upon the hollows and ravines, &c., from which they cannot be enfiladed. By the section and elevation, figs. 161 and 162, it may be seen, that the flanking caponniere is very strong, being a casemated work for two tiers of guns; each flank has five guns in the lower tier for flanking the ditch, and five in the upper tier for flanking the terre-pleins of the counterguards. The casemates in the faces or angular parts are loop-holed for musketry. Each caponniere serves as a good barrack for 160 men, besides stores. This work is completely covered in front by the counterguard or ravelin, which is only 2 feet lower than the body of the place. Each flank of the enceinte (fig. 160) contains six

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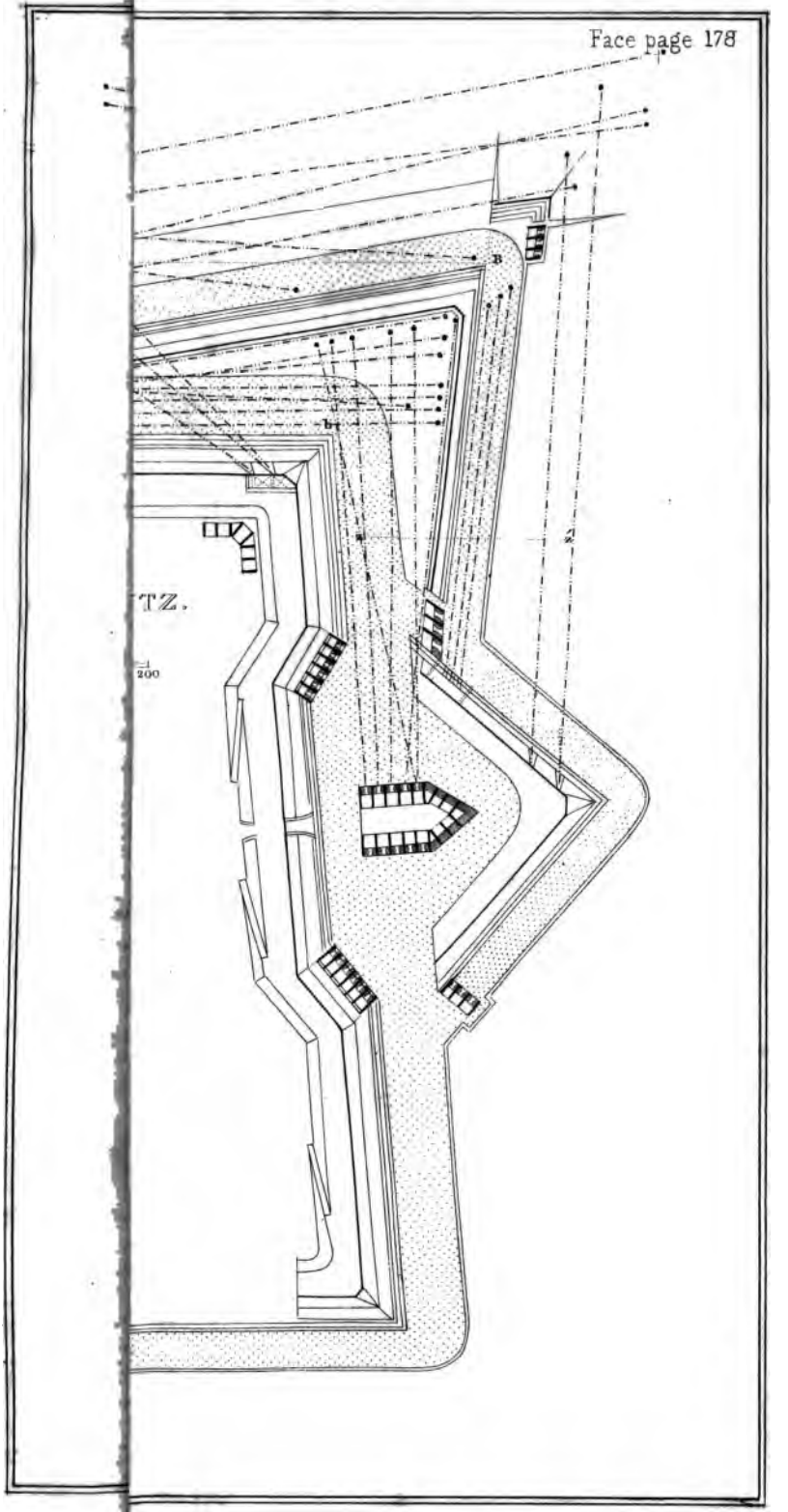


casemates for guns to flank the ditches before them. The faces and ditches of the ravelins are flanked by solid casemated caponnieres, which cover the body of the place from any batteries that might be established at the rounding of the counterscarp of the ravelin. The ditches of the counterguards are flanked by casemated batteries, placed in the faces of the ravelins. The body of the work is an oblique parallelogram, about 5° from a right angle: the side fronts are about 420 yards, and the rear front 500 yards in length, in order to suit the ground. There is a strong casemated tower at the gorge connected with a communication from Fort Constantine. There is no covered-way; the counterguards answer the purpose. Good ramps and other arrangements are made in the countersloping glacis and its salients, favourable for sorties. The sections (figs. 163, 164, and 165) show the general elevations and profiles of the work.. It is calculated that 5,000 men would be sufficient to man all these works on both sides of the river; while it is evident that a vast army might be securely cantoned within the circuit of the works. A great number of trees have been planted all around Fort Alexander; the roots of which, left in the ground, would defy the ordinary work of sappers and miners; and would therefore prove formidable obstacles in the process of a regular attack, while the timber would be invaluable in a siege.

CHAPTER X.

FORDS.—PILE BRIDGES.—TRESTLE BRIDGES.—BRIDGES OF BOATS.—BRIDGES OF PONTOONS.—FLYING BRIDGES.

232. The passage of rivers, especially of large rivers, is one of the most difficult operations in the movements of armies. It not unfrequently happens that in rivers of considerable magnitude fords may be found by which cavalry, and even infantry and artillery can pass; and in this case, if the bottom be good, the operation of crossing, though somewhat tedious, is not difficult.

To be passable for artillery, a ford should not exceed 2 feet 4 inches in depth; for infantry, 3 feet; for cavalry, 4 feet. The existence of fords and their situations will be most easily ascertained from the inhabitants of the neighbourhood; but when the desired information cannot be obtained from this source, a careful examination of the river should be made. The most likely positions for the occurrence of fords are the straight parts of rivers between two bends in opposite directions.

Rivers, in mountainous countries, though occasionally shallow, are in general so much embarassed by large stones as to be difficult for cavalry, and impassable for carriages. In sandy soils, the bottoms of the rivers are usually soft-moving sand, or fine loose gravel. Such fords are dangerous and deceitful. If large bodies of troops have to pass, the sand stirred up by the operation, will, especially if the current be strong, be quickly carried away, the depth gradually increased, and the ford, which was passable for the head of the column, may become altogether impassable for the rear.

A river unfordable in any part directly across, may sometimes be forded in an oblique direction between two bends in contrary directions.

A ford should always be marked, that troops in crossing may not wander from it into deep water. This will be best effected by a line of stakes, at moderate distances, driven into the bottom at either side of the ford, and a rope, passing the whole way across, fastened by a turn round the head of each stake.

233. When a river, which cannot be forded, must be crossed, a bridge becomes necessary; and in all cases it is better, if possible, to cross by a bridge than by a ford, unless the latter be exceedingly shallow. Military bridges may be of three kinds, 1st. Fixed structures of timber. 2nd. Floating bridges. 3rd. Flying bridges.

234. Timber bridges may be either supported on piles or on trestles. Pile bridges are the most secure, and where bridges are required to remain in use for a considerable period, as those which may be constructed on the lines of communication of an army, with its base of operations, this form of bridge will generally be adopted. To construct a good pile bridge over a considerable river, much skilled labour is necessary, and an ample supply of materials essential. When the bottom of the channel is firm, and the river not subject to floods, a pile bridge may be constructed without difficulty, and will be very durable.

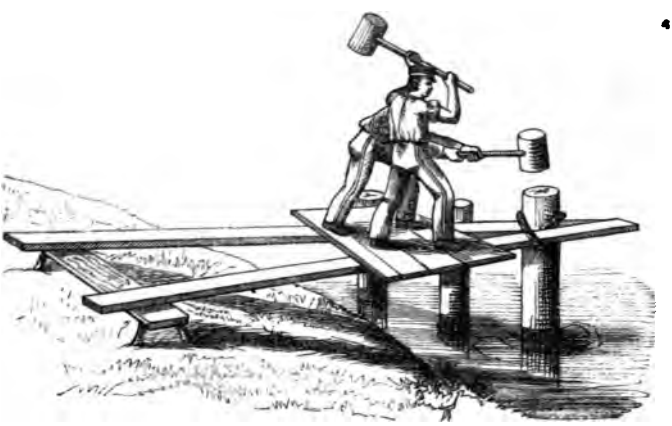
235. The piles must be driven by an engine, which may be constructed of an 8-inch or 10-inch shell run full of lead, suspended by a rope over a pulley. This may be worked by hand, and will drive piles to a depth sufficient to allow of the passage of the heaviest artillery over the bridge. The pulley of the pile engine should be supported on a framework, some 16 feet high, which may be made to act as a guide to the shell during its fall, and also for the pile while it is being driven. This framework should be erected upon a large flat-bottomed boat. If such a boat is not to be procured, a raft must be made to answer the purpose.

236. When timber of a considerable length can be procured for the joists of the bridge, it will be advisable to make the intervals between the piers or rows of piles, as great as the length of the joists will allow, so that the current of the river may be impeded as little as possible, and its action on the bridge be reduced to a minimum. By this arrangement, too, as much space as possible is given for the pas-

sage of floating bodies, and the danger of their damaging the bridge is proportionately diminished. When all the piles have been driven as far as the power of the engine can accomplish, they must be sawn off to the same level, and the superstructure of timber be strongly and carefully fitted. With bays of 20 feet, and a roadway 14 feet wide, there must be at least five or six beams not less than 7 inches by 8. With wider bays, timbers of larger dimensions will be necessary. The planking should be not less than 2 inches thick laid transversely.

237. Bridges on piles, for the passage of infantry over shallow rivers only, may be expeditiously constructed, as the piles may be slight, 6 inches in diameter would suffice, and they can be driven by hand by heavy mauls, or by two men using a beetle. See diagram, Fig. 166.

FIG. 166.

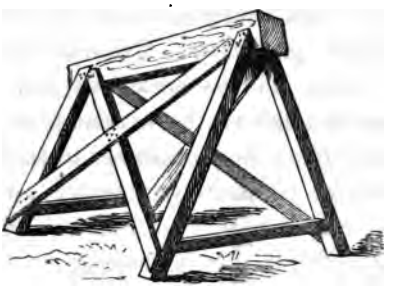


Here the pile is set and kept in its place by means of two spars of planks resting their extremities upon a stool placed on the bank. A plank is then laid across, on which one or two men may stand to drive the pile. The weight of the men, which may be increased, if necessary, by stones placed on the platform assisting to force the piles into the ground. When one row of piles is placed, and the floor laid to a cross beam fixed upon them, another row may be set and driven in the same manner, fixing the stool on that part of the floor which will thus have been completed. Piles driven in this way may be safely depended upon to bear infantry on a front of two or three files with open ranks, not keeping step.

238. Bridges on trestles. When rivers are shallow, and not liable to sudden floods, and when their channels are firm and even, very

useful bridges may be constructed on trestles. Trestles for this purpose should each consist of a stout transom or ridge piece some 8 inches square and 16 feet long; to this should be fitted four legs adapted to the depth of the river, all splaying outwards from the vertical, and strengthened by diagonal bracing, (Fig. 167.) For large bridges it

Fig. 167.



will be found advantageous to add an additional pair of legs to each trestle. These, from the difficulty of fitting six legs to the uneven surface of the bottom of the river, should not be attached until the trestle is placed in position, they should then be driven into the bed of the river, and their upper extremities should be firmly nailed to the ridge piece.

When the different parts of the trestles are all prepared beforehand, they can be speedily put together and the bridge completed with great expedition.

When the intervals or bays are ten feet, the dimensions of the trestle and beams may be as under:—

		Length.	Breadth.	Thickness.
Trestles.	1 Head beam	16	8	8
	4 Legs	*	4½	4½
	6 Braces	—	—	—
	Balks	12	4½	4½
	Planks for floor	12	12	2

If there be a strong current, a cable should be stretched across the river on each side of the bridge, and the trestles be firmly lashed to them. It may, moreover, sometimes be necessary to load the trestles with shot or stones, to keep them in their position until the flooring is laid upon them.

239. Floating bridges are those generally adopted for the passage of troops over rivers. They may be very expeditiously constructed, and can be made strong enough to carry the heaviest artillery. During the last century boats were generally used for this purpose; and, although on navigable rivers, boats are almost always to be found, it was frequently a work of time and difficulty to collect a sufficient number, particularly if the enemy had had the opportunity of removing or destroying them previously. The inconveniences and delays resulting from this cause, always hazardous and often fatal to the success of an expedition, led to the introduction of regular bridge equipages or pontoon trains, duly organized to accompany the march of armies. An efficient pontoon train renders an army independent of the rivers which may intersect its route. By its aid rivers of very considerable magnitude may be bridged in a few hours, and a march of a given distance may thus be with certainty completed in a given time, a matter often of momentous importance to the general strategic combinations of a campaign.

240. Bridges of boats. Boats of almost any kind will make a serviceable bridge; but it is desirable that they should bear a proportion in size to the magnitude of the stream over which the bridge is to be made. For wide rivers the boats should be large. The boats of which a bridge is constructed should, if possible, be nearly of the same size, unless they are all very large, and then variations in dimensions will be of little consequence. Should some be large and some small, the passage of large bodies of troops, of heavy guns and ammunition waggons will depress them unequally, causing the flooring of the bridge to assume an irregular line, straining and injuring, and in some cases fracturing, the timber and destroying the bridge. When boats, all of the same size, cannot be obtained, the larger boats should be placed at wider intervals, so that they may sustain a heavier weight, proportioned to their greater capacity, during the passage of troops, and be depressed to an equal distance with the smaller.

241. The superstructure will consist of balks of timber laid across the gunwales of the boats, and securely fastened, and the flooring of planks laid transversely over.

A certain rigidity results from this arrangement, by which, if the boats were subject to much motion, the bridge would be speedily destroyed. In tidal rivers, where a considerable swell must generally

be encountered, this manner of securing the timbers is not allowable. In this case it will be found advantageous to erect a trestle or support in the centre of each boat, over which the timbers may be bolted to each other: thus each boat will be allowed independent motion, and this will not endanger the fracture of the bridge.

The boats should be moored head and stern, and should be kept at their relative distances by timbers fixed at the head and at the stern, stretching across the bays, so as to remove unnecessary strain from the timbers of the bridge.

242. The timbers should be as nearly as possible square, and of dimensions proportioned to the space of the intervals. With good timbers, 8 inches by 6, twenty feet may be allowed from trestle to trestle. The width of the bridge should also be proportioned to the dimensions of the timbers. With five balks of 7 inches by 8, the bridge should not exceed 14 feet in width. If too wide there will be danger of the beams being broken by the overcrowding of troops on the bridge.

243. When there is no regular pontoon train, and boats cannot be procured, rafts may be used in place of boats. These rafts may be made of casks, which, if properly arranged and securely lashed will answer all the purposes of pontoons. Eight or ten casks, all of the same size, should be placed side by side on a level piece of ground, touching each other, bung-holes uppermost. Two stout balks, 4½ inches square, and about 2 feet longer than the sum of the diameters of the casks which are to form the pier, must then be prepared and laid along the upper surface of the casks, parallel to each other, and each about a foot distant from the line of the bung-holes. A piece of 3 inch rope should then be attached to one end of each of these balks, passed under all the casks, and secured to the other end of the same balk.

Fig. 168.

These ropes are then drawn up towards the balks and tightly lashed

by small ropes between every pair of casks, and the smaller ropes of the one side are again lashed across to those of the other side (Fig. 168). The whole pier thus becomes so compact that it may be rolled and launched and rowed with as little danger of breaking up as though it were a single pontoon. Piers of casks constructed in this way may be used exactly like pontoons, and will form a most efficient bridge.

244. Pontoons are vessels of various forms and dimensions, and are made of various materials. They are generally boat-shaped, of wood, of copper, or of tin, sometimes with decks, and sometimes without. Each boat, or pontoon, is carried on a suitable waggon, which also conveys the portion of superstructure necessary for one bay or interval.

Blanshard's pontoons are cylindrical vessels of tin, with conical or hemispherical ends, divided by diaphragms into several compartments, by which they are both strengthened and rendered less liable to destruction, as to be sunk they must be pierced in several places.

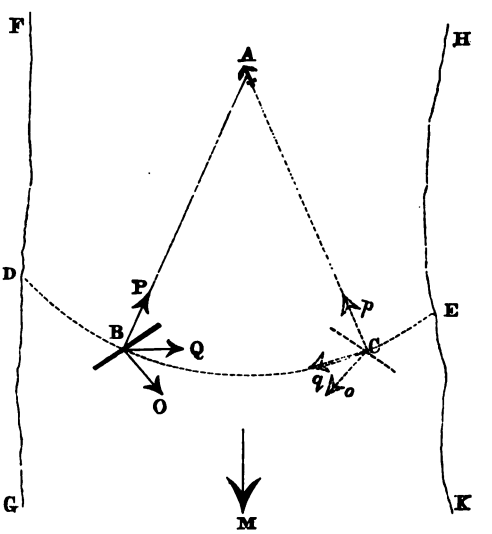
Each pontoon has a saddle or wooden frame which is attached to the pontoon by girths of canvas. This receives the ends of the balks, which are fixed by bolts, and then covered by planks or chesses, which are themselves secured to the balks by rack lashings. These pontoons are easily carried, are quickly formed into a bridge. Their whole buoyancy too is available, as they cannot be filled with water, a risk inseparable from the use of open pontoons, especially in rapid streams.

245. Francis's army floating waggons. A very ingenious proposal has recently been made, and experimented upon with great success, to introduce, for the general purposes of army transport, waggons which may also serve as pontoons or boats. The bodies of these waggons are rectangular in form, made of corrugated copper or iron, and are capable of being readily detached from their carriages. Being impervious to water, they can cross deep fords without injury to their contents. From their large capacity their buoyancy is great; they can be used singly as boats to ferry troops over rivers, or joined in pairs as rafts will carry field artillery; in fours, heavy artillery. They can be used as pontoons, and will form a very firm and buoyant bridge. They are exceedingly strong, little liable to injury, and very difficult to overset.

246. Flying bridges. A flying bridge is an arrangement by which a stream with a good current may be crossed, when, from a want of

time or a deficiency of materials, it may not be possible to form a bridge. It consists of a large boat or raft firmly attached by a long cable to a mooring in the centre of the stream, if the channel be straight, or on the bank if the channel be curved. By hauling the boat or raft into proper positions, it will be driven across the stream in either direction as may be desired.

FIG. 169.



Let F G, H K (Fig. 169), be the banks of a stream, of which the direction of the current is indicated by the arrow-head at M. Let A be an anchor, or strong pile, firmly driven into the bed of the river. To this pile is attached one end of a rope or chain A B., of which the other extremity is fastened to a raft. Suppose the side of the raft to have an inclination (which should be about $54\frac{1}{2}°$) with the direction of the current, as at B in the diagram.

Now the action of the current on the side of the raft will be perpendicular to the side of the raft, and may be represented by a force in the direction B O. The tension of the rope or chain will be a force in the direction B P. These two forces in the directions B O, B P, are equivalent to a single force in some intermediate direction, B Q, tending to drive the raft across the river from D to E.

When the raft has arrived at E, its position must be changed by moving its sides through an angle of 90°, into the new position shown by the dotted lines in the diagram at C. Here, under the influence of

an exactly similar system of forces, the raft will be driven across in the opposite direction from E to D.

A good flying bridge requires rather a strong current, and when this is present, bodies of troops may thus be passed over rivers of moderate size. But it is an operation too tedious to be generally adopted when the bodies of troops are large and the rivers wide.

For small rivers a single boat will be sufficient for a flying bridge. On large rivers a raft should be made of two large boats or barges fixed some 10 or 12 feet apart, with a strong stage or deck, extending over the whole. By a flying bridge of this kind a considerable body of men may be carried across at each trip.

With wide rivers the cables must be long, and supported at intervals on buoys or casks.

CHAPTER XI.

CASEMATES—POWDER MAGAZINES—REVETMENTS.

247. Guns mounted on the open ramparts of a fortress, even when well traversed, are liable to be speedily destroyed by an enemy's vertical and enfilade fire. The only known means by which this can be prevented, is by placing the guns in casemates or vaulted apartments of masonry, solid enough and strong enough to resist the effects of the fall and explosion of heavy shells.

And, although there are many objections against the general introduction of casemated batteries, they seem to be outweighed by the imperious necessity of protecting the guns from enfilade and vertical fire. For, in all recent constructions and projects for new fortifications, casemated cover for the guns is unsparingly adopted.

In a fortress intended to sustain a regular siege, it is further necessary to provide bomb-proof cover for the garrison, when off duty, for the hospitals, storehouses and magazines. For all these purposes except the last, casemates are necessary.

Casemates then are long, narrow apartments of masonry, very solidly constructed, under the mass of the rampart of a fortress, from 18 to 20 feet in width, 9 feet in height, covered by an arch, at least 3 feet thick in the thinnest part. When used for batteries, the front wall must be 8 to 10 feet thick, and the rear of the casemate should be entirely open. For other purposes, casemates should be made in the least exposed and driest parts of a fortress, and the greatest must be paid to their ventilation. There should be windows at both ends, to insure a thorough draft of air. In regular

fronts, the best positions for casemates are the curtains and flanks, as the revetment in these parts is not liable to be breached. Casemates may be made in cavaliers when the revetment is covered in front by the faces of the bastions, also in the faces of bastions and ravelins when covered by counter guards.

The objections generally made to casemated batteries are these :—

248. 1st. That when they can be seen from a distance, as they must be when used for any other purpose than the flanking of ditches, they may be speedily destroyed by a direct fire of heavy shot, and cannot be repaired when damaged.

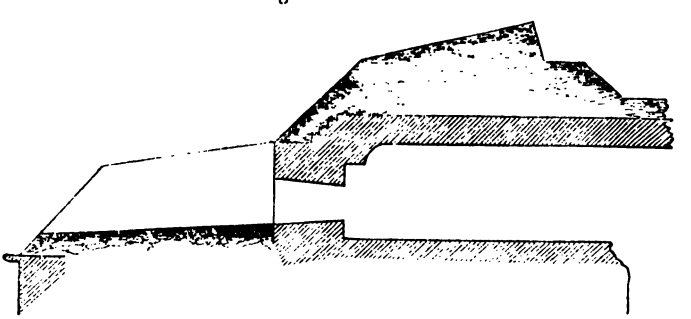
2nd. That they weaken the rampart under which they are constructed, and that, when their arches are ruined by the breaching batteries of the assailant, the whole mass of rampart and parapet above sinks down into the casemates and exposes the interior of the work.

3rd. That firing is necessarily very slow, for the interior of the casemate is soon filled with smoke, which must be allowed to clear away between each round, or the gunner would be driven from the casemate.

4th. That the splinters detached from the cheeks of the embrasures and from the interior walls of the casemates by an enemy firing at and through these embrasures, are very destructive to the men serving the guns.

249. The first of these objections is doubtless true, and there are

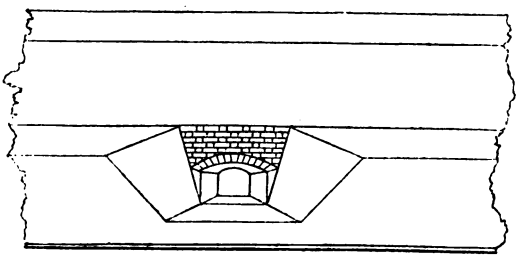
Fig. 170.
Longitudinal Section.



many instances of the speedy destruction of casemates when battered by heavy guns from the land; but the result may be in a great

measure obviated by the formation of the caesmates a la Haxo, as shown in the diagram, Figs. 170 and 171. The masonry wall of the

FIG. 171.
Elevation.



battery is in this construction covered in front by a regular parapet of earth provided with embrasures corresponding with the openings of the embrasures of the casemates. Thus, the whole front is covered by an earthen parapet, with the exception of the masonry arch immediately over the embrasure, which is unprotected and must remain so unless the experiments now in progress for covering the fronts of casemates with shot-proof wrought iron, give a satisfactory solution to the difficulty.

The second objection may probably be removed by the proper construction of the casemates. If built as well and as solidly as they should be, it will be a difficult matter to destroy them to the extent contemplated in this objection.

The third objection appears to be overrated. With casemates properly constructed, open at the rear, the smoke clears away fast enough to be of no great practical inconvenience, though it hangs about the mouth of the embrasures, and obscures the view unless there be a breeze to remove it.

The fourth objection admits of no remedy, so long as the part exposed to be struck by the shot is of masonry. It would be in a great measure removed, could iron, as mentioned above, be substituted for it.

250. For sea-coast defences, especially when the depth of water is not sufficient to allow vessels to come within 800 or 1,000 yards casemated batteries may be used with advantage. Experience shows that unless ships can come close in shore, they cannot destroy well-built masonry forts. The forts at the harbour of Sebastopol sustained the united effects of the fire from the British and French fleets, numbering twenty-five vessels, for four hours, with little or no material

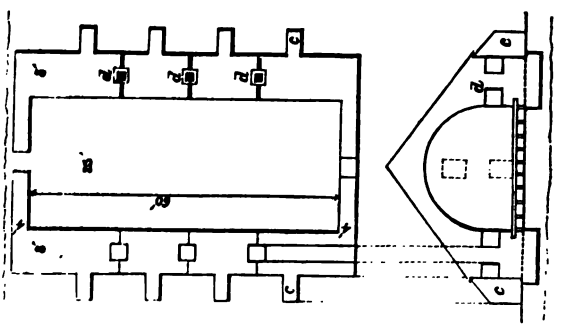
material damage. This may result from several causes. 1st. The motion of the vessels renders the practice, when at a considerable distance, far from accurate, so that it is impossible to breach the work systematically. The shot, therefore, instead of being directed time after time to the same spot, and made to cut the masonry in horizontal and vertical lines, are pretty uniformly distributed over the surface of the whole work. Each shot then knocks off a few inches of masonry only at the spot where it strikes, and does no general damage to the work.

2nd. Solid shot only are of any use; shells, rockets and incendiary missiles break into fragments on striking the masonry, and do no kind of harm except when they may chance to pass through an embrasure. On the other hand, the ships are sure to be severely handled; projectiles of every kind, hot shot, shells rockets, may be fired into them with full effect, and from the steadiness of the platforms, and the size of the objects, no single shot need be thrown away. The recent introduction of heavy rifled guns would appear then greatly in favour of coast defences against an attack by ships. From the steadiness of the guns and the size of the ships, every shot from the batteries could be made to tell on the ships, even at great distances, while from the motion of the vessels and the insignificant height of the batteries, there will be little danger of their receiving injury from the ships.

POWDER MAGAZINES.

251. Powder-magazines are isolated buildings, of a construction so solid as to resist the fall and bursting of shells. They should be placed in situations as far removed as possible from the fronts likely to be attacked, and surrounded by every precaution to render them as little liable to injury or accident as possible.

FIG. 172. FIG. 173.



Vauban's principal magazines are 60 feet long by 25 feet wide (figs. 172 and 173); the interior height of the wall, above the floor, is 6 feet to where the spring of the arch begins: the long walls, or piers, are 8 feet thick, strengthened exteriorly by four counter-forts, *c c*: the masonry is 3 feet thick at the thinnest part of the arch; and about 8 feet at the angle, over the key of the arch. The end walls are 4 feet thick; in one is a door and a window; and a window in the other: no iron is admitted into the construction, the doors and windows being lined with sheet copper: the floor is supported on rows of small brick pillars, so as to keep it dry, and give a free circulation of air under it: the magazine is ventilated by air-holes *d d*, cut in the side walls, so as to leave a solid die of masonry in its centre; and being further protected by perforated sheets of copper, nothing can be insinuated through these openings. Powder being a most delicate agent, and readily imbibing atmospheric moisture, every means must be used to obtain good ventilation and equal temperature for it. The powder is usually piled in tiers of three barrels: Vauban's magazine, just described, will thus hold 1,050 barrels, or 100,000 lbs. of powder. As a further security, the whole building is surrounded, at a distance of 12 feet from its walls, by a wall of 10 or 11 feet in height.

The arches of powder magazines in the British dominions have never been made so wide as 25 feet, and, therefore, whenever a considerable interior capacity was required, the body of the building has generally been formed of two or more arches connected together by intermediate doors or passages left in the piers.

252. Expense Magazines are required in various parts of the work to contain enough ammunition for the daily expenditure of the garrison. They are usually bomb-proof, arched masonry chambers, and are placed wherever required in positions as secure as circumstances will admit.

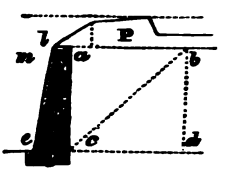
REVETMENTS.

253. Permanent works are almost invariably furnished with wide and deep ditches to secure them from sudden assault. That these ditches may present the requisite obstacle to an enemy, their sides must be nearly if not quite perpendicular, and they should be of such

a depth or height as to render descent and ascent very difficult and dangerous. To insure this, the counterscarps should not be less than 12 feet, nor the escarps than 30 feet. It will, therefore, be obvious, that in ditches of this magnitude with perpendicular sides of so great a height, strong, heavy walls will be necessary, to give adequate support to the sides, and to prevent them from crumbling away, and taking that natural slope which, if left to themselves, they would quickly assume.

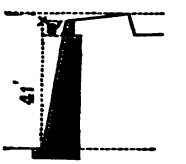
254. These strong, heavy walls or revetments are made of various profiles, as shown in the annexed diagrams. The most common and most generally applied is that known as the full revetment, Fig. 174., where the wall extends from the bottom of the ditch to the foot of the exterior slope of the parapet, usually in the same plane with the crest of the glacis. The revetment shown in this diagram, is the sloping revetment of Vauban.

Fig. 174.



The revetment is sometimes carried up to the foot of the superior slope, as shown in Fig. 175, and it is then called an entire revetment. This is an excellent construction on fronts not liable to attack, or in positions where the revetment is concealed from an enemy's view, as the additional height thus obtained renders escalade impracticable.

Fig. 175.



When the ditches are wet, or it is imperative to economise masonry, low revetments and long exterior slopes are sometimes applied, as in

Fig. 176.

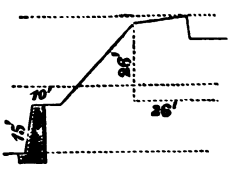


Fig. 177.

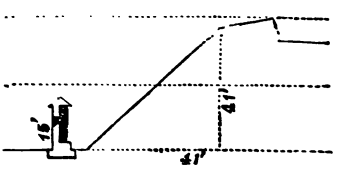


Fig. 176. This construction is called a demi-revetment. When applied to a dry ditch, it offers a small obstacle only to an attack by escalade.

In several systems, revetments altogether separated from the ram-

Fig. 178.

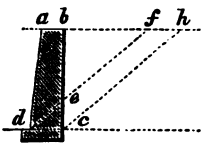


Fig. 179.

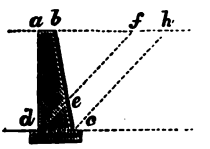
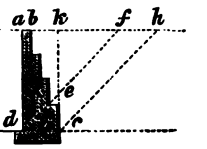


Fig. 180.



part, are advocated. These are called detached revetments, Fig. 177.

255. Revetments, whether full, entire, or partial, may have any of the profiles shown in Figs. 178 to 182, that is, the back may be vertical and the front sloping, as Fig. 178, called a sloping revetment; or the front may be vertical and the back sloping, or in steps, Figs. 179, 180, called a counter-sloping revetment.

Or the back and front may be vertical and parallel, as in Fig. 181, called a rectangular revetment; or the back and front may be parallel, and leaning, as in Fig. 182, called a leaning revetment.

Fig. 181.

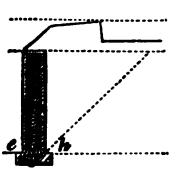
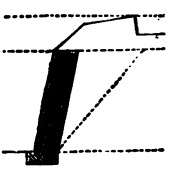


Fig. 182.



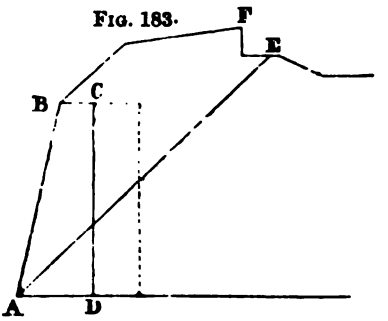
In any of these cases, it is usual to expend part of the masonry only in the wall, and part in the formation of counter-forts or buttresses, running back from the wall into the mass of rampart behind. These counter-forts add much to the stability of the wall, and binding with the mass of the rampart, increase greatly the difficulty of overturning it.

256. These strong heavy walls, on account of the material and labour expended in their construction, form a very considerable part of the expense of a fortress. It is, therefore, most important to dispose the masonry in the most advantageous manner, so as to secure the maximum of strength with the minimum of material.

No matter what the form of the revetment may be, the mass of earth to be supported by it will be that part of the rampart and

parapet which is cut off by a plane passing through the extreme foot of the revetment, and inclined to the horizon at that angle at which

Fig. 183.



the earth of which the rampart is formed would stand without support. Shown in section in the diagram by the figure A E F B.

Now, it is not possible to calculate (from the absence of sufficient data) the exact amount of pressure which such a mass of earth would exert on the back of a revetment; but it is quite possible to calculate approximately the amount of resistance which any given form of revetment can offer, and of course that form of revetment which being equal in other respects, will support the greatest pressure applied to its back, will be the most economical.

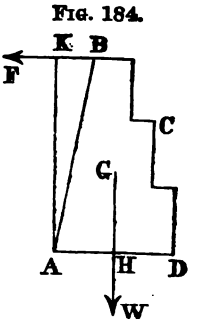
257. To determine the stability of a revetment, *i.e.*, the pressure applied to its back, which will just not overturn it.

In the determination of this problem, the revetment is supposed homogeneous, so that the weight of any length may be assumed proportional to the area of its section.

The revetment is considered as one block, so that it may be turned over without fracture, also friction with and adhesion to the soil behind it are neglected.

Let A B C D, Fig. 184, be a section of any wall required to find the force applied at B in the direction B F, which will just not overturn it about A.

Fig. 184.



Let G be the centre of gravity of A B C D.

Let W represent the weight, and A the area of the section. Draw G H vertical, meeting A D in H, and A K meeting B F in K.

Now, W applied at G in the direction G H, and F applied at B in the direction B F, must keep the area A B C D in equilibrium.

$$\text{Therefore } F \times A\,K = W \times A\,H, \text{ or } F = W \times \frac{A\,H}{A\,K}$$

A K is the height of the wall, and is therefore constant, and W is proportional to A the area of the section, whence F varies as A H × A.

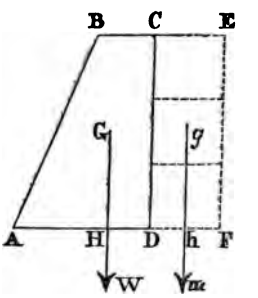
Therefore, generally,

The stability of any revetment is measured by the area of the section, multiplied by the horizontal distance from its foot to a point vertically under the centre of gravity of its section.

258. To determine the stability of any wall with counter-forts :—

Let A B C E F D be a section through a counter-fort of a wall with counter-forts, G the centre of gravity of the wall, g that of the counter-fort, and G H, $g\,h$ vertical. Also, let the distance of the counter-forts, apart from centre to centre, be equal to n times the thickness of a counter-fort, so that the counter-forts occupy altogether $\frac{1}{n}$th part of the length

Fig. 185.



of the wall. Let a be the area of the section of a counter-fort, then $\frac{a}{n}$ will be the area of the section of a continuous counter-fort, which, provided its centre of gravity be in the same line with that of the counter-forts at intervals, will be equivalent to them.

The additional stability given to the wall by the counter-forts will be measured by $\frac{a}{n} \times \mathrm{A}\,h$.

And the stability of the wall with counter-forts will be measured by $\mathrm{A} \times \mathrm{A\,H} + \frac{a}{n} \times \mathrm{A}\,h$.

Whence the following rule may be deduced :—

259. To determine the stability of a wall with counter-forts :—
Find the stability of the wall without the counter-forts, as in the last article.

Then find the centre of gravity of the section of the counter-fort, and through it draw a vertical line to the base.

Divide the distance (from centre to centre) of two adjacent counter-forts by the mean thickness of a counter-fort, and divide the area of a

section of the counter-fort by this quotient. The quotient so obtained, multiplied by the length of the line intercepted between the foot of the wall and the vertical through the centre of gravity of the counter-fort, will be the measure of the stability added by the counter-forts. And this quantity, added to that found for the stability of the wall, will be the measure of the stability of the wall with counter-forts.

260. From these considerations it will be apparent, that of the revetments commonly in use, the sloping are the strongest—the counter-sloping the weakest; and that great additional stability is obtained by the use of counter-forts.

The chief objection to sloping revetments, is the injury they suffer from the action of the weather, the coping stone being little or no protection; but it is a question, whether this inconvenience is not over-balanced by the far greater stability which they manifestly possess.

FIELD REVETMENTS.

261. The interior slopes of the parapets of permanent and field-works, as well as in some cases the sides of the ditches of the latter, require revetments, to enable them to stand at that slope which is necessary, and to endure the action of the weather.

The materials made use of in the construction of these revetments, are fascines, gabions, hurdles, sods, sand-bags, and timber. In siege operations, and in fact in all operations in active warfare, vast quantities of these materials are required, and are daily consumed, in the construction of breastworks, parapets, batteries, magazines, and a variety of miscellaneous purposes. Large quantities, then, must be prepared or manufactured by the ordinary troops of the line, superintended by their own officers, who should be acquainted with all the details necessary for their production.

262. Fascines, are strong, close, regular, faggots, carefully and compactly made, generally of green brushwood. They should be straight cylindrical and pliant; bound round with good thick, unbroken gads or withes, of pliant wood, at equal distances, the knots well tied, and all in one line; no variation in girth exceeding 1 inch to be allowed.

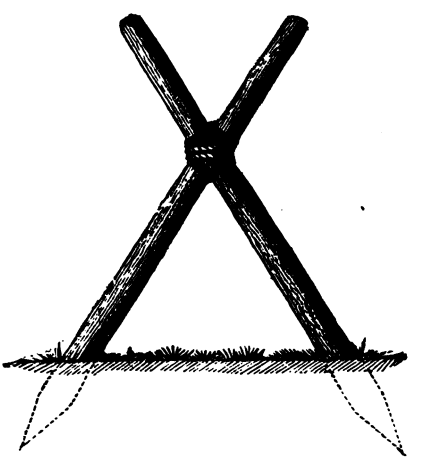
Fascines are of several kinds and various dimensions, according to the purposes for which they are intended. The most common are the long fascines or saucissons, 18 feet long, 9 inches in diameter, about 140 lbs. in weight; such a fascine can be made by five men in one hour, including the cutting of the wood when at hand.

Water fascines, 18 inches in diameter, 6 to 9 feet long.

Trench fascines, 4 or 5 feet long, 6 inches in diameter. Sap faggot, 3 feet long, 9 inches in diameter, having a sharp pointed stake, passed longitudinally through the centre and projecting a foot or so beyond the extremity of the fascine.

To make good fascines requires considerable practice and much care and attention. The process is this: Stakes are driven into the

FIG. 186.



ground, obliquely, in pairs (Fig. 186), so that the stakes in each pair cross at the same height above the ground about 3 feet, where they are firmly bound together, forming a row of trestles each in shape like the letter X.

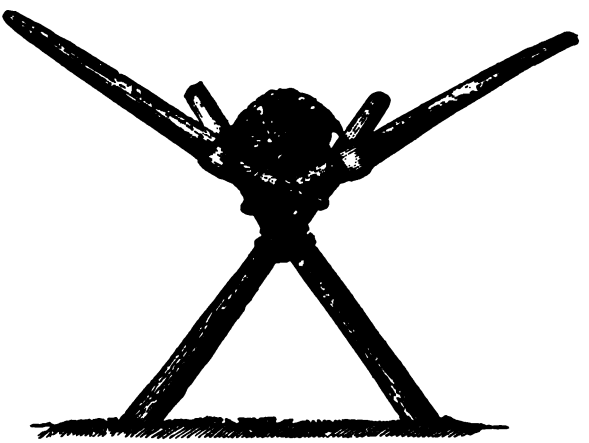
These trestles should be placed about 4 feet apart when the brushwood is good; closer together when it is bad. Thus five trestles at least will be requisite to prepare 18 feet fascines.

A choker must now be prepared. This is made by fastening by an iron ring, each extremity of a chain about 4 feet long, to an ash

stake. Each stake is 4 feet long, and the point where the chain is fastened is about 18 inches from the thicker end.

Two small rings are attached to the chain 28½ inches apart (equal to the circumference of the fascine), and equidistant from its middle point.

Fig. 187.



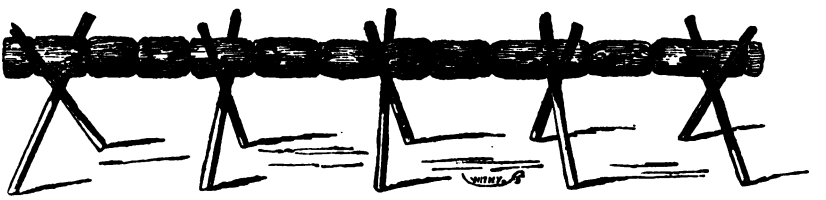
In choking the fascine the middle of the chain is placed under it, and the ends brought over and crossed as in the diagram. Two men, one on each side, then bearing on the longer arms of the levers tighten the chain and compress the fascine to the proper dimensions, that is until the rings on the chain meet. A third man now binds the fascine as close as possible to the choker, with a strong gad, or with stout spun yarn, when the choker may be removed and the operation repeated at the proper intervals, generally 18 inches.

263. For withes or gads to bind fascines, very straight rods must be selected, they should be 5 feet long, not thicker at the thickest part than the thumb, nor thinner at the thinnest than the little finger. To prepare them for use, place the thick end under the foot, and twist the rod from the top downwards, by which the rod will become flexible and capable of being securely knotted without fracture. The knot to be formed in fastening the gad round the fascine is shown in the annexed diagram.

FIG. 188.

264. To make the fascine, the brushwood is laid in the trestles, the longest and straightest rods being kept round the outside, the inferior

FIG. 189.



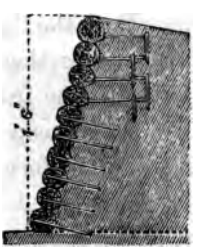
material in the middle. The proper quantity of brushwood having been thus carefully arranged, the choker is applied near the extremity of the fascine, and subsequently at intervals of 18 inches as already mentioned. The ends and exterior are now neatly trimmed by the handsaw and bill-hook, and the fascine is complete.

When good gads or withes cannot be procured, stout well tarred spun-yarn may be substituted for them.

With fascines are prepared bundles of stakes, called fascine pickets, in the proportion of six to each fascine, they should be 4 feet long $\frac{1}{2}$ inch in diameter, and be cut to triangular points.

265. Slopes to be revetted with fascines have usually a base equal to one-fourth their height. The fascines are placed horizontally one over another, as the work is built, until the whole slope is covered by one layer of fascines. Pickets are driven through each fascine to secure it to the work, and these are sometimes fastened to other pickets, buried vertically in the mass of parapet, as shown in the diagram.

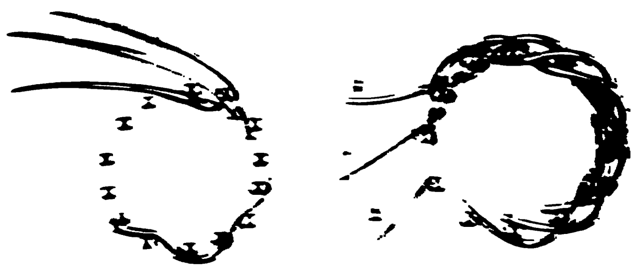
FIG. 190.



266. To find the number of fascines required to revet any slope, divide the length of the slope by the length of the fascine, and the

[illegible]

Fig. [illegible]



The method of working will be best understood by reference to the annexed diagram.

Each one passes outside two, and inside one, [illegible] and the three are twisted together like a rope.

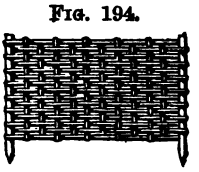
[illegible] In arranging with gabions, [illegible] right angles to the slope, so that when standing upon this, their surfaces will be coincident with the slope. When one row of gabions has been thus placed, and the earth has been as high as their upper surfaces, a row of fascines is laid horizontally upon the tops of the row of gabions. Above these again another row of gabions is placed at the same inclination with the former, and finally another row of fascines completes the whole.

Fig. [illegible]

Two rows of gabions and two of fascines, are required for the revetment of an interior slope, of the usual height, without a banquette, and one row of gabions and two of fascines with a banquette; therefore in the former case, the number of gabions required, will be equal to the number of feet of crest to be revetted, and in the latter case to half that number. The number of fascines in either case, will be equal to twice the length of the slope divided by the length of a fascine.

269. Hurdles are the common coarse wicker hurdles made for farming, and other purposes, usually 3 or 4 feet high and 6 to 9 feet long. They are useful in temporary works, to retain earth at a steep slope, for a short time. When thus used, they should be secured by anchoring pickets. Hurdles are moreover useful, to form a dry footing in trenches, during wet weather; in the passage of wet ditches, and for many similar purposes.

FIG. 194.



Hurdle.

270. Sods or turfs are used for the formation of the interior slopes of parapets, and the cheeks of embrasures. Sods should be cut from fine close turf, with thickly matted roots, previously mown, and if possible, watered, to make the earth adhere more closely to the roots of the grass.

The sods are laid, with the grass downwards, alternately headers and stretchers, like bricks in a wall. Their under or upper surfaces, should be perpendicular to the slope of the parapet, and not horizontal, except in a vertical revetment, and each sod should be fastened to those beneath, by two or three wooden pegs. Sod work can be made with great perfection, and is very durable.

The arrangement of the sods is shown in plan and in rear elevation in Fig. 195, and in side elevation in Fig. 196.

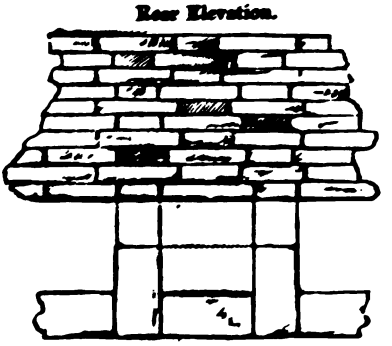
In meadows, the dimensions of sods may be 12 to 18 inches long, 12 inches wide, and 4 to 6 inches thick. In heath, having large roots, they may be 2 feet long, 12 or 18 inches wide, and 8 to 10 inches thick.

To find the number of sods required to revet any given length of slope, the revetment being one sod thick :—

Divide the height of slope by thickness of sods, for the number of rows.

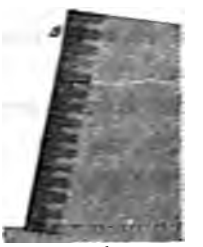
Divide twice the length of the slope by the sum of the length and breadth of a sod for the number in one row.

Fig. 195.
Rear Elevation.



Plan.

Fig. 196.



Length 16", width 8", thickness 2½"

Multiply these two quotients together, for the whole number.

271. Sand-bags are coarse canvas bags, of a capacity sufficient to hold about a bushel of earth; when empty they occupy only a small space and are frequently of great use. A good field revetment can be built with filled sand-bags, laid as sods, such a revetment, however, is only fit for temporary purposes, as the sand-bags soon rot; they are unfit for lining the cheeks of embrasures, as the flash of the guns speedily destroys them. In rocky positions, it is sometimes necessary to construct entire batteries and parallels with filled sand-bags. In the annexed diagram, are shown a section of a parapet revetted with sand-bags, and an enlarged plan of the same.

Fig. 198.

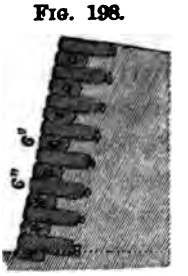
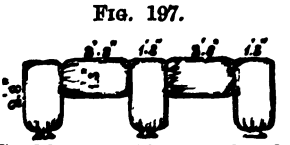


Fig. 197.



Sand-bags should be tarred, and hold one cubic foot of earth.

Many of the British trenches and batteries before Sebastopol, owing to the rocky nature of the ground, were formed of sand-bags. baskets, casks, &c., filled with earth brought from a distance. Sand-bags are used in great numbers, laid on the superior slopes of parapets, to form loop-holes for riflemen.

272. Timber is used for revetments, in particular cases only, as where it may be considered advisable in important field works, to retain the escarp of the ditch at a steep slope. In this case, a revetment is necessary, which may be constructed of beams or the trunks of small trees, planted 3 or 4 feet deep, vertically in the ground and touching each other, or by lining the surface of the slope, with planks secured by stout posts, 3 or 4 feet apart, planted several feet in the ground, and there fastened to heavy horizontal beams. The strength of the revetment may be still further increased, by connecting the upper extremities of the posts, to others buried under the mass of the rampart.

GLOSSARY OF TECHNICAL TERMS USED IN FORTIFICATION.

Abattis—are rows of felled trees, of a considerable size. Their stems strongly bound together and picketed down, and their branches pointed and interlaced as much as possible.

Advanced Covered Way—is a terre plein, on the exterior of the advanced ditch, similar to the first covered way.

Advanced Ditch—is an excavation beyond the glacis of the enceinte, having its surface on the prolongation of that slope, that an enemy may find no shelter when in the ditch.

Advanced Lunettes—are works resembling bastions or ravelins, having faces and flanks. They are formed upon or beyond the glacis.

Advanced Works—are such as are constructed beyond the covered way and glacis, but within the range of the musketry of the main works.

Ammunition—is a term which comprehends gunpowder, and all the various projectiles and pyrotechnical compositions and stores, used in the service.

Angle of Defence—is that formed by the meeting of the flank and line of defence, or the face of the bastion produced.

Angle of the Polygon—is that formed by the meeting of two of the sides of the polygon; it is likewise called the polygon angle.

Balks—are joist-shaped spars, which rest between the cleats upon the saddles of two pontoons, to support the chess or flooring.

Banquette—is the step of earth within the parapet, sufficiently high to enable the defenders, when standing upon it, to fire over the crest of the parapet with ease.

Barbette.—Guns are said to be in barbette when they are elevated, by raising the earth behind the parapet, or by placing them on a high

carriage, so that instead of firing through embrasures, they can be fired over the crest of the parapet. In this position, the guns have a wide range, instead of being limited, as in firing through embrasures.

Barricade—is an obstruction formed in streets, avenues, &c., so as to block up access to an enemy. They are generally formed of overturned waggons, or carriages of any description, large stones, breastworks, abattis, &c.

Barriers—are strong gates, so placed as to secure the entrance to a work.

Bastion—is that part of the enceinte, which is formed by two faces and two flanks, all the angles being salient. In a more extended sense, it is any projection from the general outline of the fortress, from which the garrison is enabled to see and defend, by a flanking fire, the ground before the ramparts, right and left.

Bastion (*Demi*)—is that which has only one face and one flank, cut off by the capital, such as terminate the extremities of horn and crown works.

Bastion (*Empty*).—When the mass of rampart and parapet follows the windings of the faces and flanks, leaving an interior space in the centre of the bastion, on the level of the ground, it is called a hollow or empty bastion. In standing in a bastion, and looking towards the country, the face and flank on the right hand are called the right face and flank; and on the left hand, the left face and flank.

Bastion (*Flat*).—When the demi-gorges and gorge are in the same line, and the former is half of the latter, the work is called a flat bastion.

Bastion Forts—are the most perfect of closed field works, with reference to flanking defences, as each side or front consists of two faces, two flanks, and a curtain.

Bastion (*Full*).—When the interior space is filled up to the level of the terre plein of the rampart, the construction is called a full bastion.

Batardeau—is a strong wall of masonry built across a ditch, to sustain the pressure of the water, when one part is dry and the other wet. To prevent this wall being used as a passage across the ditch, it is built up to an angle at top, and armed with iron spikes; and to render the attempt to cross still more difficult, a tower of masonry is built on it. In the batardeau is the sluice-gate, by the opening or closing of which the manœuvres of the water can be regulated.

Battery.—A battery, in fortification, is a number of pieces of artillery placed behind a parapet, for the purpose of firing on an enemy, or on the works of an enemy. In field service the term is applied to a certain number of pieces of artillery, whether in position or otherwise.

Berm—is a narrow level space, a few feet wide, between the foot of the parapet and the scarp of the ditch, to prevent the mass of earth of which the parapet is formed, from sliding into the ditch.

Blindage—is a temporary bomb or splinter-proof roofing, constructed of timber and the like, to give cover to magazines, batteries, &c.

Blockade.—A place is said to be blockaded by land or sea, when all ingress or egress is prevented by troops, or ships of war surrounding it.

Blockhouse—is a small fortified kind of barrack, frequently used as a keep, or place of final defence in a field work. They are a species of retrenchment, peculiarly adapted to wooded countries, the materials for their construction being found on the spot.

Bomb—(see *Shell*).

Bombard—is to throw bombs or shells into a place, with a view to its destruction, and to compel it to surrender.

Bonnet—is a term applied to a small work with two faces, placed before the salient or flanked angle of a work.

Boom—is a chain of masts, or a large cable, or other obstacle, stretched over a river or mouth of a harbour, for the protection of a military bridge which has been thrown across, or to bar access.

Boyau—is a small trench, or a branch of a trench, leading to a magazine, or to any particular point. They are generally called boyaus of communication.

Breach—is an opening made by artillery, or by a mine, in the walls and defences of a fortified place.

Break Ground—is to commence the siege of a place by opening trenches, &c.

Breastwork—is a hastily-constructed parapet, not high enough to require a banquette, or at least generally without one.

Bridge Head (*la tete du pont*)—is a work consisting of one or more redans or bastions, constructed on the bank of a river, to cover a bridge, to protect a retiring army in crossing the river, and to check an enemy when pressing upon it.

Camouflet—is a small mine, of about 10 lbs. of powder, sufficient to compress the earth all around it, without disturbing the surface of the ground. It is sometimes formed in the wall or side of an enemy's gallery, in order to blow in the earth, and to cut off the retreat of the miner.

Canister Shot—are iron bullets, packed in a tin case, fitted with a wooden bottom, of the size of the bore of the piece for which they are prepared. They are also called case shot.

Capital—The line drawn, bi-secting the salient angle of a work, is called the capital.

Capitulation—The surrender of a fortress, or an army, on stipulated conditions.

Caponniere—is a passage across a dry ditch, from the tenaille to the gorge of the ravelin, which is covered on each side by a demi-caponniere, or a parapet, furnished with a banquette, for the defence of the ditch; and having a long slope terminating like a glacis.

Carcasses—are shells filled with a furiously burning composition, intended to fire buildings, &c.

Casemates—are bomb-proof apartments for cannon, for barracks, for hospitals, &c. They are usually constructed under the ramparts, in positions which are not liable to be breached. They are much used in modern fortresses for flanking ditches, the embrasures for the guns being pierced through the revetment.

Casemated Caponnieres—are vaulted galleries leading across a ditch, to the gorge of some outwork, or to some gallery or casemate in the counterscarp. The term is also applied to vaulted bomb-proof buildings, constructed in ditches of fortresses, with embrasures for artillery or loop-holes for musketry, to flank the ditches in which they are formed.

Case Shot (see *Canister Shot*).

Cavalier—is a term applied to a work of more than ordinary height. It is sometimes constructed upon the terre-plein of the bastion, with faces and flanks parallel to those of the bastion, over which it has a command of fire. Cavaliers are not confined to bastions, but are placed wherever a great command of fire is required, and are sometimes traced straight, on other occasions curved.

Centre Angle of the Polygon—is the angle formed by the meeting of the two oblique radii.

Centre of the Bastion—is the intersection made by the two demi-gorges.

Chamade—is a signal made for parley by beat of drum.

Chamber of a Mine—is a cell of a cubical form, made to receive the powder.

Chemin des Rondes—is a berm from four to twelve feet broad, at the foot of the exterior slope of the parapet. It is sometimes protected by a quickset hedge, but in more modern works by a low wall, built on the top of the revetment, over which the defenders can fire, and throw hand grenades into the ditch.

Chesses—are the platforms which form the flooring of military bridges. They consist of two or more planks, ledged together at the edges, by dowels or pegs.

Chevaux-de-Frize—is a kind of fence, principally used in field fortification. It consists of a beam of wood with several rows of strong staves, radiating from it like the spokes of a wheel, pointed at their extremities, frequently with iron. They are used for defending a passage, stopping a breach, or to form an intrenchment against cavalry.

Circumvallation (*Line of*)—is the name given to a belt of field works facing outwards, formerly thrown up, about two miles from the place invested, by a besieging army.

Citadel.—A citadel is a small strong fort, constructed either within the place, or on the most inaccessible part of its general outline, or very near to it; it is intended as a refuge for the garrison, in which to prolong the defence, after the place has fallen.

Command—denotes the height of a work above the level of the natural ground, or above any work in its front.

Command of Fire.—When a work has a sufficient elevation over the work before it, to enable the defensive weapons to act in both works at the same time upon an advancing enemy, even to the foot of the glacis, then the inner work is said to have a command of fire over the other.

Command of Observation.—When the interior work has only sufficient elevation to look into or even over the work before it, but not sufficient to fire clear of it, then it is said to have only a command of observation.

Contravallation (*Line of*)—is the name given to a belt of field works, thrown up around and facing the place immediately invested, to render the besiegers secure against surprise.

Cordon—is the coping of the escarp or inner wall of the ditch, sometimes called the magistral line; as from it, the works in permanent fortification are traced. It is usually rounded in front, and projects about one foot over the masonry: while it protects the top of the revetment from being saturated with water, it also offers, from projection, an obstacle, to an enemy in escalading the wall.

Counter-Battery.—When a number of guns are placed behind a parapet, for the purpose of dismounting or silencing, by direct fire, the guns in an enemy's work, it is called a counter-battery.

Counterforts—are the buttresses by which the revetment walls are backed and strengthened interiorly.

Counterguard—is a work composed of two faces, forming a salient angle, sometimes placed before a bastion, sometimes before a ravelin, and sometimes before both, to protect them from being breached.

Countermines—are galleries excavated by the defenders of a fortress, to intercept the mines, and to destroy the works of the besiegers.

Counterscarp—is the support of the side of the ditch next the country, and in permanent fortification is usually of masonry.

Counterslope.—In the case of a revetment, the slope is within instead of on the outside; and is usually formed in steps. In the case of a parapet, the slope is upwards instead of downwards.

Coup-de-main—is a sudden and vigorous attack; for the purpose of an instantaneous capture of a position.

Coupures—are short retrenchments made across the face of any work, having a terre plein. The ditch of the coupure is carried quite across the terre plein, and through the parapet of the work in which it is formed, but not through the revetment.

Covered Way.—The covered way is a secure road of communication all round the fortress outside the ditch, having a banquette, from which a grazing fire of musketry can be brought to bear, upon every part of the glacis.

Crater of a Mine—is the excavation or cavity formed in the ground, by the explosion of the powder.

Cremaillere—is an indented or zigzag outline.

Crenellated—loop-holed.

Crown-work—is a similar work to horn-work, but consisting of two fronts instead of one. It is connected to the main works in a similar way, and is used for the same purposes as the horn-work.

Crows' Feet—are iron-pointed stars, or stout nails, so fixed as to

radiate, that in any position they may have a point uppermost. They are strewed on the ground over which cavalry may be expected to pass.

Crotchets—are openings cut into the glacis at the heads of traverses, to enable the defenders to circulate round them. These passages are closed by a gate when necessary.

Cunette—is a narrow ditch in the middle of a dry ditch, to keep it drained, as well as to form, especially when filled with water, an obstacle to an enemy.

Curtain.—The curtain is that part of the rampart of the body of the place, which lies between two bastions, and which joins their two flanks together.

Curtain Angle—is that formed by the meeting of the flank and the curtain.

Dam.—A dam is an impediment formed of stones, gravel, and earth, thrown across a stream of water, by which it is made to overflow its banks, in order to inundate the adjacent ground.

Dead Angle or (Dead Ground)—is any angle or piece of ground which cannot be seen, and which therefore cannot be defended from behind the parapet of the fortification.

Deblai—is the quantity of earth excavated from the ditch to form the remblai. Under ordinary circumstances the one is equal to the other, but not always; as, from the nature of the soil, earth may have to be brought to supply the remblai.

Defilading—consists in raising the parapets of a fortress or field work, or in depressing the terre pleins so much, as to conceal the interior of the work from the view of an enemy on an elevated position. It also consists in directing the magistral lines of its parapets towards points, where local impediments, as rivers, marshes, lakes, &c., would prevent a besieger from constructing batteries. The former is defilading by relief, the latter is termed defilading by the trace or plan.

Demi-Lune—is the name formerly given to the ravelin.

Detached Bastion—is one which is separated from the enceinte by a ditch.

Detached Works—are those which are constructed beyond the range of the musketry of the main works; and as a constant and steady communication with them cannot be kept up during a siege, they are frequently left to their own resources; nevertheless, they ought to exercise a general influence on the defence of the place.

Diminished Angle—is that formed by the exterior side and the line of defence.

Ditch—sometimes called the Fosse—is the excavation made round the works, from which the earth required for the construction of the rampart, parapet, and banquette is obtained.

Elevation.—The elevation of a work is the projection of its face on a vertical plane by horizontal rays. It shows the height or depth of a work, and also its length, when the plane of projection is parallel to the face.

Embrasures— are openings made in the parapet for the cannon to fire through.

Enceinte—is the body of the place, or the first belt of ramparts and parapets that enclose the place.

Entanglement.—An entanglement is formed by cutting half through the stems of trees, and pulling the upper parts to the ground, to which they are then picketed.

Epaulement—is an elevation of earth thrown up by a besieging army, to cover troops in flank, which are posted for the protection of the trenches, from the fire of the enemy. It is a term applied to various earthen works of merely passive defence, such as the short returns or shoulders, generally constructed at the flanks of a field battery.

Escalade—is a term given to the assault of a fortified place, when scaling ladders are used.

Escarp or (*Scarp*)—is the side of the ditch next to the place; which, in permanent fortification, is usually faced with masonry.

Expense Magazines—are small powder magazines containing ammunition, &c., made up for present use. There is usually one in each bastion.

Exterior Side—is the side of the polygon, upon which a front of fortification is formed.

Faces of the Bastion—are those portions of the bastion, which are laid off on the lines of defence.

Faces of the Ravelin—are those portions of the work, which form the salient or flanked angle of the ravelin.

Fascine—is a long cylindrical faggot of brushwood, used to revet the interior of batteries and embrasures, and for many other purposes of military engineering.

Fausse-Braie—is a second enceinte, exterior to, and parallel to the main rampart, which has a command of fire over it.

File—is a line of soldiers drawn up behind one another. The general term means two soldiers, consisting of the front and rear rank men.

Fire (*Direct*).—Direct fire is when the battery of guns is ranged parallel to the face of the work, or the line of troops to be fired at, so that the shot strike it perpendicularly.

Fire (*Enfilade*).—Enfilade fire is when the battery is ranged perpendicularly to the prolongation of the crest of a parapet, or to a line of troops, so that the shot flies in the same direction, or parallel to the line or parapet, sweeping along from one end to the other.

Fire (*Oblique*).—Oblique fire is when the battery of guns is ranged, so as to form an angle with the front of the object to be struck.

Fire (*Plunging*).—Plunging fire is when the shot is fired from a position, considerably higher than the object fired at.

Fire (*Ricochet*).—Ricochet fire is firing with a slight elevation, and with small charges, in a direction enfilading the face of a work, so that the shot are pitched over the parapet, and bound along the rampart from end to end, with destructive effect on the guns and gunners.

Fire (*Reverse*).—Reverse fire is when the shot strikes the interior slope of the parapet at an angle, greater than 30°.

Fire (*Slant*).—Slant fire is when the shot strikes the interior slope of the parapet, forming with it a horizontal angle, not greater than 30°.

Fire (*Vertical*).—Vertical fire is that, in which the shot or shell describes a lofty curve through the air, before it falls: such is the fire from mortars.

Flanks of the Bastion—are those portions of the bastion which join the faces to the curtains, and by their position, are well situated for flanking the main ditch.

Flank (*Retired*).—The retired flank is traced, within the line of the regular flank of the bastion, and is protected by an orillon, on its outer extremity.

Flanked Angle—is that formed by the meeting of two faces of a work (such as a bastion), which angle is salient towards the country, and is defended by some other part of the works.

Fleche (or *Arrow*)—is a small work with two faces, forming a

salient angle, sometimes thrown up at the foot, or even beyond the glacis, for the purpose of giving cover to a musketry fire, from an advanced position. It communicates with the covered way at the salient angle, by a traversed passage through the glacis.

Flying Bridge—consists of one or more barges, moored by a long cable to a point, in the centre of the stream. When the barge is properly steered, in a current sufficiently strong, it is swept by it from one bank to the other.

Flying Sap—is a sap formed, by placing and filling several gabions at the same time; which may be done at times, when the defence is slack. The term is also applied to the usual formation of the second parallel, in the attack.

Fort—is an enclosed work of the higher class of field works. The word, however, is loosely applied to other military works.

Fortification—is the art of constructing military works, either for offensive or defensive purposes; the object being to increase the power of the assailants or defenders, through their instrumentality.

Fortification (*Front of*)—consists, of all the works constructed upon any one side of a regular polygon, whether placed within or without the exterior side; or, according to St. Paul, all the works contained between any two of the oblique radii. Some authors give a more limited sense to the term 'front of fortification,' by confining it to two half bastions joined by a curtain. If the polygon be regular, that is, if all the sides be of equal length, and the fronts of the same description, it is called a regular work; but if they differ, it is called an irregular work.

Fortification (*Irregular*)—is that, in which, from the nature of the ground or other causes, the several works have not their due proportion according to rule; irregularity, however, does not necessarily imply weakness.

Fortification (*Natural*)—consists of such objects formed by nature, as are capable of impeding the advance of an enemy; and a station is said to be naturally fortified, when it is situated on the top of a steep hill, or surrounded by impassable rivers, marshes, &c.

Fortification (*Regular*)—is that in which the works are constructed on a regular polygon, and which has its corresponding parts equal to each other.

Fortress.—A fortress is a fortified city or town, or any piece of ground so strongly fortified as to be capable of resisting an attack carried on against it, according to rule.

Fougass.—A fougass is a small mine, which is lodged ten or twelve feet underground. Sometimes it consists of one or more loaded shells placed in a box, and buried in the ground. They are used for the purpose of checking an assault, &c.

Fraises—are palisades placed horizontally or obliquely, at the edge of a ditch on either side, or projecting from the exterior slope of a parapet. If the slope be very long, there are sometimes two rows of fraises used.

Fuse—is a tube filled with a peculiar combustible composition, especially used in firing shells. It is cut or bored to a length, proportioned to the intended range of the shell, so that it shall burn down and explode the bursting charge, just as the shell strikes the ground, or earlier if desirable. There is also another kind of fuse, called "Bickford's fuse," which is a small tube of gunpowder, sewed round with tarred twine, and then pitched over, It is not injured by damp, and when well made, will burn under water, and is used for firing the charges of mines, &c.

Gabion—is a cylindrical wicker basket, open at both ends, used to revet the interior slopes of batteries, the cheeks of embrasures, and also in the formation of the parapet of trenches, in sapping.

Gallery of Mine—is the passage leading from the shaft or entrance of the mine, to the place where the powder is deposited. It is generally, but not always made, in a horizontal direction.

Garrison.—The guard of a fortified place, or the place itself, is frequently so called.

Glacis.—The glacis is the parapet which protects the covered way from the fire of the enemy, and which also conceals the masonry of the upper part of the scarp revetment. Its slope is very gentle, and consequently very wide, extending from its crest to the natural level of the ground.

Gorge of the Bastion—is the distance between the inner extremities of the two flanks.

Gorge Demi of the Bastion—is the line which is formed, by the prolongation of the curtain, until it meets the oblique radius.

Grape Shot—are of two patterns, either the balls are quilted round an iron pin, with a circular plate at the bottom (the size of the bore of the gun), or a pin runs through a succession of plates, between every two of which is a tier of balls. In the latter case, they are also called "tier shot."

Grenade—is a small shell flung by hand, properly called hand grenade.

Ground Plan (see *Section*).

Gun—is a cannon; in military language the name is never applied to small arms.

Gun Cotton—is common cotton, steeped in a mixture of sulphuric acid and nitric acid, and when properly soaked, is well washed in running water, and then dried. The explosive force of three parts of gun cotton equals that of eight parts of gunpowder.

Gunner—is a soldier employed to manage and discharge pieces of ordnance.

Gunpowder—is composed of 75 parts of nitre, 15 of charcoal, and 10 of sulphur.

Horn Work—is a work composed of two half bastions and a curtain or a front of fortification, with two long sides called branches or wings, directed upon the faces of the bastions or ravelins, so as to be defended by them. This work is placed before a bastion or ravelin, and serves to enclose any space of ground or building, which could not be brought within the enceinte.

Howitzer—is a piece of artillery shorter than a gun, but much larger in calibre than a gun of the same weight used for projecting shells.

Hurter—The hurter is a piece of timber, from six to ten inches square, placed along the head of a gun platform, at the foot of the interior slope of the parapet, to prevent the latter from being injured, by the wheels of the gun-carriage.

Interior Side—is the line drawn from the centre of one bastion to that of the next, or the line of the curtain produced, to the two oblique radii of the front.

Interior Flanking Angle—is formed by the line of defence and the curtain.

Intrenched Camp—A position is so called when selected by an army, and strongly fortified for its protection, during the operations of a campaign; one of a more permanent nature is sometimes formed outside a fortress, but within the range of its guns, to prevent the garrison from being confined within the walls of the place.

Intrenchment—is a general term, denoting a ditch or trench with a parapet, for purpose of defence.

Inundation.—An inundation or collection of water is produced, by forming across a stream, one or more dams.

Invest.—To take the initiatory measures to besiege a town, by securing every road and avenue leading to it, to prevent ingress or egress.

Ladder Bridge—may be formed, by running a cart or gun limber into the stream, and securing it there, with the shafts in a vertical position, by ropes from both sides of the river; one end of a ladder from each bank resting upon it, and covering the steps or rungs with planks.

Limber.—The fore part of a travelling gun-carriage, to which the horses are attached.

Line of Defence—is the line which extends from the angle of the polygon or extremity of the exterior side, through the inner end of the perpendicular to the flank of the bastion.

Line of Least Resistance (*The*)—is that which is supposed to extend, from the centre of the charge of a mine, to the nearest surface of the ground.

Lines.—A connected series of field works, whether continuous or at intervals.

Lines at Intervals—are lines composed of separate field works, so arranged, as to flank and defend one another.

Lines Cremaillere—are composed of alternate short and long faces, at right angles to each other.

Lines of Bastion—as the name indicates, are formed of a succession of bastion-shaped parapets, each consisting of two faces and two flanks, connected together by a curtain.

Lines of Tenailles—consist of parapets, forming a series of salient and re-entering angles.

Lodgment—is an intrenchment hastily thrown up, on a captured breach or outwork, in order, to maintain the position against recapture.

Loopholes—are apertures formed in a wall or stockade, that through them, a fire of musketry may be directed on the exterior ground.

Loopholed Galleries are vaulted passages or casemates, usually placed behind the counterscarp revetment, and behind the gorges of detached works, having holes pierced through the wall, to enable the defenders to bring a musketry fire from unseen positions, upon the assailants in the ditch. Loopholes, however, are not confined to

galleries. In modern fortifications, the revetments, both scarp and counter-scarp, are very generally pierced for a musketry fire.

Lunette—is a work larger than a redan, with two faces and two flanks. It is much used as an advanced work, in field fortification, and it is sometimes placed on the capitals of the works in permanent fortification, in advance of the glacis, to cover some ground which it is desirable to occupy.

Machicoulis—is a projecting wall, parapet, or balcony, with holes between the corbels which support it, through which missiles can be directed down on the head of an enemy, at the foot of the wall.

Magazine—in the general acceptation of the term, is a place, in which ammunition, stores, arms, and provisions are kept; but the name is frequently restricted to a place for the preservation of powder.

Magistral Line—in a plan, is that which regulates the form of the works. It is that which is first laid down, and from which the other parts of the works are traced. It usually coincides with the cordon.

Mantlet—is a musket-proof shield of metal, which is sometimes used for the protection of sappers or riflemen, during the attack of a fortress.

Martello Towers—are buildings of masonry, generally circular, and of various dimensions. They are chiefly placed on the sea coast, having a gun on their summit, mounted on a traversing platform, by which it can fire in any direction.

Masked Battery—is when the battery is so concealed or disguised, as not to be seen and recognised by the enemy, until it opens its fire.

Merlon—is the space in the parapet between two embrasures.

Military Bridge—is a bridge formed of pontoons, casks, boats, or rafts of timber, placed at certain distances, according to their strength and buoyancy, across a river, to serve as piers. These are connected together by pieces of timber, called balks and dividers, and the whole covered with planks, called chesses, which are kept in their places by side pieces of scantling, called ribbons, which are rack-lashed to the dividers. The space between the piers is called a bay.

Mines (*Military*)—are cavities filled with powder, placed in, or under works, so as to destroy them when fired. In attacking a fortress, when the besieger has advanced near enough by sap, and intends to proceed by mining, a shaft is sunk to the necessary depth, from the bottom of which a gallery is run out, the length and direction required; the earth being supported by linings of wood, or mining

cases. At the extremity of this gallery, the charge is lodged; from which a fuse is carried to the surface (or wires, if the voltaic battery is employed), and the gallery carefully tamped.

Mining—is the art of executing subterranean excavations, and other measures appertaining to the destruction of works or buildings, by charges of powder lodged within them, or in the ground beneath them.

Mortar—is a short heavy piece of ordnance, generally of large calibre, used for throwing shells at a high elevation.

Mortar Bed—is the carriage or bed on which a mortar rests. It is made either of wood or iron, and is of great strength.

Musket—is an infantry fire-lock.

Ordnance—is a name applied to everything connected with the artillery service. Cannon are frequently designated pieces of ordnance.

Orillon—is a projecting tower at the shoulder angle of a bastion, covering the flank from exterior view, frequently found in old fortresses.

Outline or Tracing—is the succession of lines that show the figure of the works, and indicate the direction in which the defensive masses are laid out, in order to obtain a proper defence.

Outworks—are such works as are constructed between the enceinte and the glacis, of whatever kind.

Palisades—are strong palings from six to nine inches apart. They are frequently placed at the foot of slopes, to present an obstacle to an enemy. Usually the interior slope of the glacis and the traverses in the covered way are furnished with palisades of a triangular shape, square pieces of timber being cut diagonally to supply them. They should stand as high as the crest, are pointed at their upper ends, and are secured above to a horizontal piece of timber called a ribbon. Their lower ends are firmly secured to a beam sunk about two or three feet under the banquette. In field fortification, the rough stems of young trees are sometimes used.

Parados—is a traverse covering the interior of a work from reverse fire.

Parallels—in the attack of a place, are wide trenches, which afford the besieging troops a free covered communication between their various batteries and approaches, and a secure position for the guards of the trenches.

Parapet—is the covering shot-proof mass of earth, on the exterior side of the rampart; usually about 7½ feet high, to cover the defenders. It should be sufficiently high, both in field and permanent works, to protect the interior from the fire of the enemy; and so thick, that no shot within his reach can pass through it. The thickness will, therefore, be regulated, by the power of the enemy's guns to penetrate it.

Park (*Artillery*).—Artillery park is the name given to the whole train of artillery material, belonging to an army in the field; and to the depôt set apart to contain them.

Park (*Engineer*).—Engineer park is the name given to the whole equipment of stores, tools, &c., belonging to the engineer department in the field; and to the depôt assigned to them in camp.

Patrole.—A small party of men, under the charge of a subaltern or non-commissioned officer, detached from the guard for specific objects.

Perpendicular.—The perpendicular is a line drawn perpendicularly, from the point of bi-section of the exterior side, towards the place; its length being proportionate to the extent of the exterior side, and the number of sides of the polygon.

Pierrier—was a term originally applied to an engine for casting stones; then to a small kind of cannon; now to a mortar for discharging stones, &c.

Piquets—are small detachments of troops, posted on the front and flanks of an army in the field, in order to guard against surprise, and to keep reconnoitering parties of the enemy at a proper distance.

Places of Arms—are enlargements in the covered-way, at the re-entering and salient angles of the counterscarp; hence the terms re-entering places of arms, and salient places of arms; the latter space is formed simply by rounding the counterscarp; and the former by setting off demi-gorges of thirty yards (more or less), and making the faces form angles of 100° with the adjoining branches of the covered-way.

Plan.—A plan shows the tracing; also the horizontal lengths and breadths of the works; the thickness of the ramparts and parapets; the width of the ditches, &c.: it exhibits the extent, division, and distribution of the works; but the depth of the ditches, and the height of the works, are not represented in a plan.

Plan of Comparison—is a plan of a fortress, and of the surrounding country, on which are expressed the distances of the principal points

from a horizontal plane, imagined to pass through the highest or lowest points of ground, in the survey. This imaginary plane is called a plane of comparison.

Plane of Defilade—is a plane supposed to pass through the summit or crest of a work, and parallel to the plane of site.

Plane of Site.—The general level of the ground, or ground line, upon which the works are constructed, is called the plane of site, whether that plane be horizontal or oblique to the horizon.

Platform—of a gun or mortar, is the floor of wood or stone on which the cannon is placed. It should have a gentle rise to the rear, to check the recoil of the gun, and to facilitate the work of running it out again after loading.

Plongée.—The dip or declension of the superior slope of the parapet, is called the plongée. The amount of it is regulated, by the distance of the nearest spot, to which the fire of musketry is to be directed; that is, generally, the exterior edge of the ditch in front of it.

Polygon of Fortification.—Every piece of ground to be fortified, is surrounded by a polygon, either square, pentagonal, hexagonal, &c., according to the number of its sides, which are called exterior sides; upon these the fronts of fortifications are constructed.

Pontoons—are buoyant, portable vessels, used as floats for supporting the platform of a military bridge. They are usually hollow cylindrical vessels of tin, about 24 feet long, and 2 feet 8 inches in diameter. They are divided into air-tight compartments in the interior. Each pontoon has a wooden frame, called a saddle, securely lashed to it lengthwise, to which the balks and dividers, that extend from one pontoon to the other, are bolted. Two pontoons, (or piers, formed of empty casks) with their balks, dividers, saddles, chesses, &c., form a raft.

Postern (or Sally Port)—is a passage usually vaulted, and constructed under the rampart, to afford a communication from the interior into the ditch. The passages from the covered way into the country, are likewise called sally ports; as they afford free egress and ingress to troops, engaged in making a sally or sortie.

Profile (see *Section*).

Rack-Stick and Lashing—consist of a piece of two-inch rope, about 6 feet long, fastened to a picket about 15 inches long, having a hole in its head to receive the rope. Rack-lashings are used for

securing the planks of a gun or mortar platform, between the ribbons and the sleepers.

Radius (*Oblique*).—The oblique radius is a line drawn from the centre of the polygon to the extremity of the exterior side.

Radius (*Right*).—The right radius is a line drawn from the centre of the polygon, perpendicular to the exterior side.

Raft (see *Pontoons*).

Raise the Siege—is to abandon the siege.

Ramp—is an inclined plane in a rampart, to facilitate ascent.

Rampart—is the great mass of earth thrown up from the ditch inwards, in order to give the defenders a commanding position for their cannon and musketry.

Range of a Gun—is the distance the shot passes over, after leaving the muzzle, until it reaches the object it is intended to strike; or the ground, if it fall short of the object.

Rasante—is a French term, applied to a style of fortification, in which the command of the works over each other, and over the country, is kept very low, in order that the shot, may more effectually sweep or graze the ground before them.

Ravelin—is the work constructed beyond the main ditch, opposite the curtain, composed of two faces, forming a salient angle, and two demi-gorges, formed by the counterscarp. It is separated from the covered way by a ditch which runs into the main ditch.

Ravelin (*Redoubt of the*)—is a work constructed within the ravelin, but separated from it by a ditch.

Reconnoitre—is to make one's-self acquainted by personal inspection, as far as may be practicable, with the enemy's position and movements. Also to survey and draw, in a rapid manner, ground of importance to operations of war, not represented in existing maps with sufficient accuracy or minuteness.

Redan—is a work consisting of two faces, forming a salient angle.

Redan (*Double*)—is composed of two redans joined together; and thus forming a re-entering angle for mutual defence.

Redan (*Triple*)—consists of three redans joined together; the extreme faces of these are also in general longer than the others.

Redoubt—is an enclosed work, without flanking defence from its own parapets. Also a keep, or an interior retrenchment, such as the redoubt in the ravelin.

Re-entering Angle—is an angle pointing inwards, or towards the work.

Re-entering Angle of the Counterscarp—is that formed by the intersection of the two lines of the counterscarp, opposite the curtain.

Relief—is the height to which the works are raised. If the works are high and commanding, they are said to have a bold relief; but if the reverse, they are said to have a low relief. The relief should provide the requisite elevations for the musketry and artillery, to insure a good defence.

Remblai—is the quantity of earth contained in the mass of rampart and parapet, and banquette.

Reserve—is a select body of troops kept back in action, to give support when needed, or to rally on, in case of a disaster.

Retrenchment—is an inner defensible line, either constructed in the original design, or executed on the spur of the occasion, to cut off a breach, or other weak point; so that the capture of the latter shall not involve that of the retrenched post.

Revetment—is the facing to the steep sides of a ditch or parapet. In permanent works, it is usually of masonry; in field works, it may be of timber, turf, hurdles, gabions, fascines, or of the natural soil, if of tolerable tenacity.

Revetment (*Demi*).—A demi-revetment is that which is raised only up to the level, or below the level of the ground.

Revetment (*Entire*).—An entire revetment is that, which reaches from the bottom of the ditch to the foot of the superior slope of the parapet.

Revetment (*Full*).—A full revetment is that, which reaches to the foot of the exterior slope of the parapet; that is, seven or eight feet above the plane of sight.

Rifle Pits—are holes or short trenches, about four feet long and three feet deep, forming, with the earth thrown out in front of them, cover for two men. There is generally a loophole on the top of the breastwork, made, by placing two sand-bags across the parapet, and a third resting on these, in the direction of it, to cover the head and shoulders of the rifleman.

Saddles for Pontoons—consist of two spars placed parallel to each other, and connected by short pieces of wood of equal dimensions; the lower surface of the saddle is cut, so as to correspond with the curved shape of the pontoon, to which they are fastened by girths.

Salient Angle.—An angle pointing outwards, or towards the country, is called a salient angle.

Sally Port (see *Postern*).

Sand-bag—is a canvas bag, usually made to contain a bushel of earth. They are used for revetting the interior slopes of batteries, repairing breaches, &c., and are frequently placed, two longitudinally, and one above transversely, on the crest of a parapet, for the protection of the men when firing with muskets.

Sap.—A trench formed as described in sapping, is called a sap. When the fire of the enemy is slack, so that many gabions may be placed and filled at the same time, it is called a flying sap. If two parapets, one on each side of the trench, be formed, it is then called a double sap.

Sap-Faggots—are fascines three feet long, placed vertically between two gabions, for the protection of the sappers before the parapet is thrown over.

Sappers and Miners—are soldiers employed in the construction of all military works, fortifications, batteries, sapping, mining, pontooning, &c. At sieges they are employed as mechanics, or as sub-directors of working parties of infantry.

Sapping—is the art of excavating trenches of approach, under the musketry fire of the besieged, which is practised by trained men, called sappers. These men place gabions, one by one, along the intended line of parapet, filling them rapidly as they are placed, with the earth excavated from the trench.

Sap Roller—consists of two large concentric gabions, six feet in length, the outer one having a diameter of four feet, the inner one a diameter of two feet eight inches, the space between them being stuffed with pickets or small billets of hard wood, to make them musket-shot-proof. Its use is to protect the squad of sappers, in their approach, from the fire of the place.

Saucisson—is a long tube of linen, filled with gunpowder, and laid in a wooden case or trough, to protect it from damp. It is used for exploding fougasses or mines. The name is also given to an extra large fascine.

Scaling Ladders—are ladders made in parts of about twelve feet in length, and capable of being joined together to obtain the length required, by placing the ends of one portion into staples at the end of another, and securing them by lashings of rope.

Scarp (see *Escarp*).

Scarp (To).—To cut down a slope, so as to render it inaccessible.

Section, Profile, Ground Plan.—If a plane pass through a work in any direction, the cut made by it is a section; if the cut be vertical and perpendicular to the face of the work, it is a ground plan; thus, when the foundation of a house appears just above the ground, it shows the ground plan of the building.

Shaft—in mining, is a perpendicular excavation.

Shells.—A shell is a hollow shot with a hole to receive the fuse. They are usually fired from mortars and howitzers, and are charged with a sufficient quantity of powder to burst them, when they reach the end of their range.

Shoulder Angle—is that formed, by the meeting of the face and the flank of a work, such as a bastion.

Shrapnell Shells—or spherical case shot, as they are also called, are shells having two compartments; one filled with musket balls, the other containing a bursting charge of powder. They are discharged from guns and howitzers, and have a fuse like that of a common shell, but shorter, in order that the shell may burst in the air, and scatter the balls, just before the completion of its range.

Siege.—The process of a deliberate attack on a fortified place, is so called.

Sluice.—A sluice is a strong vertically sliding door, placed in a batterdeau, to regulate the flowing of the water of the ditch.

Sorties—are sudden attacks made by the garrison on the besiegers, generally at night. The troops are collected in the places of arms in the covered way, and an attempt is made to surprise the working parties, and destroy the trenches.

Spherical Case Shot (see *Shrapnell Shells*).

Spike.—To spike guns, is to drive large nails, or a piece of small rod, into the vent; so as to render them unserviceable.

Splinter Proof.—Strong enough to resist the splinters of bursting shells.

Star Forts—are forts with several salient angles, in the form of a star.

Stockades—are strong timber walls, eight or nine feet high, loop-holed for musketry fire. They should be firmly secured to the ground, having sometimes a small ditch in front, and a banquette in the rear.

Storm.—To make a vigorous assault on any position, occupied by an enemy.

Strategy—The science of conducting the great operations of war.

Surcharged Mine—sometimes called a globe of compression; is a mine loaded, with a very great charge of powder.

Tactics—as distinguished from strategy, is the science of military formations and movements—the art of handling troops.

Tambour—is a stockade or timber wall, loopholed, made with two faces, forming a salient angle at the gorge of a work, to serve as a retrenchment or to cover the staircase, with a ditch in front, and sometimes with a half roof sloping to the rear, to protect the defenders from hand grenades and splinters of shells.

Tamp—To pack the excavation of a mine, after the charge has been deposited.

Tenaille—is a low work, constructed in the main ditch, upon the lines of defence, between the bastions, before the curtain, composed of two faces, and sometimes of two flanks and a small curtain.

Tenaillons—are works sometimes found constructed in old fortresses, on each side of the ravelin. The short faces being traced, on the prolongations of the faces of the ravelin, from the counterscarp of its ditch; the long faces being directed for flanking defence, to about the middle of the faces of the bastions.

Tenaillons (*Demi*)—are very similar to tenaillons, excepting that their short faces are directed, perpendicular to the faces of the ravelin, about one-third or one-half down from the flanked angle.

Terre Plein—is a name given to any space which is level, or nearly so; thus, the area on the rampart, between the banquette and the interior slope of the rampart, is called the terre-plein of the rampart.

Tier Shot (see *Grape Shot*).

Tower Bastion—is one which is constructed of masonry, at the angles of the interior polygon of some works; and has usually vaults or casemates under its terre-plein, to contain artillery, stores, &c.

Tracing (see *Outline*).

Traverses—are portions of parapets, which cross the breadth of the covered-way, at the salient and re-entering places of arms. Other traverses are also placed between these, where necessary, in order to keep their distance apart within proper bounds. Traverses are thrown up, to bar enfilade fire, along any line of work or passage, which is liable to it.

Trenches—are the approaches or excavations, made for the purpose of covering troops, when advancing to the attack of the works of a place. They are from six to ten feet wide, and about three feet deep; the earth taken out forming a parapet, on the side next to the works of the besieged, which, when near the place, is revetted with gabions.

Trestle.—A trestle is a piece of timber supported at each end by legs. Two or more of them are used, for carrying a small bridge.

Trestle Bridge—is made, by placing strong trestles in the river, or ditch, on which are laid balks and chesses.

Trous-de-Loup—or trap-holes; are rows of pits in the form of inverted cones. They should be either 2½ or 8 feet deep, so as not to be serviceable to the enemy's riflemen. They should be traced in a chequered form, and a strong pointed stake should be driven in the middle of each.

Videttes.—Sentries placed on outposts and elevated points, so as to be able, advantageously, to observe the approach of an enemy, and to give early notice of his movements.

Zigzags—are defiladed trenches, run out from the parallels of attack, so as to form a covered road, by which the assailants can approach the fortress.

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BY

MAJOR HECTOR STRAITH.

REVISED AND RE-ARRANGED

BY

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